A. I. A. File Number—12c3

GALVANIZED IRON for ROOFS and ROOF DRAINAGE

Details & Specifications

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GALVANIZED IRON *for* ROOFS *and* ROOF DRAINAGE

Commercial, Public, Residential and Industrial Types of Buildings with a Special Section on The Economy of Using Rust-Resisting Pure Iron

EDITED IN COLLABORATION WITH ARCHITECTS

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Cincinnati, Ohio

REVIEWED BY ARCHITECTS

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NOTE: The ARMCO organization maintains an Architects' Sheet Metal Service Bureau which will gladly work out with architects the sheet metal problems that may arise.

Foreword

IT is the purpose of this handbook to present such practice as will insure longer service life for galvanized iron roofing and roof drainage.

The specification by architects of branded sheets of heavier gauge, and improved construction and erection practice on the part of sheet metal contractors, have brought this type of material into greater popularity.

Acknowledgment

IN compiling and editing this manual, we have drawn upon many trade publications and handbooks dealing with sheet metal construction. This mass of construction information has been carefully reviewed and those construction practices which, in our long experience, have proved best in serving the roofing and roof drainage functions, are here presented.

This vast amount of sheet metal construction information, together with our own roofing experience, has been concentrated into a few typical problems for the convenience and ready reference of the architect and the engineer.

Obviously, some practices presented in various trade publications and booklets are likewise shown here. In other words, methods which are best and which have become more or less standard would of necessity appear here in the same form.

Also, the application of galvanized corrugated iron sheets to steel purlins and girts has become virtually standardized by the practice of large companies, as American Bridge Company, Austin Company, McClintic Marshall, and others.

Acknowledgement is made to these companies and also to Professor Milo S. Ketchum, a recognized authority on construction of mill buildings, for much of the construction practice and information contained in Part Two.

Table of Contents

Important Facts Relating to Galvanized Iron as a Material for Roofing

GALVANIZED iron roofings of proper thickness and properly installed, compare very favorable to roofings of other metals and materials, under general service conditions.

EXPANSION AND CONTRACTION: Metal roofings for which proper allowance for this factor has not been made, in many instances develop ruptures outside the seams.

As may readily be seen below, iron offers a decided advantage by its minimum reaction to fluctuating temperatures. What variation does occur can be readily taken up entirely with expansion joints that leave the sheet iron flat and true of surface at all times, at the same time causing no injurious strain to the metal.

The following table gives the coefficients of linear expansion per degree Fahrenheit, of those sheet metals commonly used for roofing purposes. The whole numbers and fractions at right are given to more readily show the difference:

IRON (Ingot Iron)	.00000717	1.
*COPPER	.00000928	1.3
*ZINC	.00001620	2.2
*LEAD	.00001624	2.3

*Marks Mechanical Engineers' Handbook, 1924.

Best available figures, and these only approximate, give for United States conditions, 200° Fahrenheit difference between the coldest cold night temperature and the hottest hot day sunlight surface temperature.

The following table gives the total contraction of sheets of the length given if laid in the hottest weather, based on the above temperature.

	Length between Expansion Joints		
	2 ft.	20 ft.	100 ft.
Total contraction for IRON	.034″	.34″	1.7″
Total contraction for COPPER	.044″	.44″	2.2″
Total contraction for ZINC	.078″	.78″	3.9″
Total contraction for LEAD	.078″	.78″	3.9″

Approximate Weight of Roofing Materials

Material	Weights*—Pounds Per Square Foot of Roof Surface
Galvanized Iron (26 gauge standing seam)	1.25
Galvanized Corrugated Iron (22 gauge)	1.75
Galvanized Iron Shingles	1.00
Copper Roofing Sheets	1.50
Copper Roofing Tiles	1.75
Terne Plate IX	.625 to .75
Lead (about ⅛″ thick)	6.00 to 8.00
Zinc (No. 20 B. W. G.)	1.50
Plain Tiles or Clay Shingles	11.00 to 14.00
Spanish Tiles (Old Style, two parts)	19.00
Spanish Tiles (New Style, one part)	8.00
Slate (3/16″ thick)	7.25
Shingles (Common)	2.50
Five-ply Felt and Gravel Roof	6.00
Four-ply Felt and Gravel Roof	5.50
Sheathing (1″ white pine)	3.00

*Weights given do not include weight of wood or other type sheathing. Weight of sheathing material is given separately at end of list.

FIRE AND LIGHTNING PROOF: According to the National Board of Fire Underwriters' estimates, a disastrous fire occurs every minute; the annual fire bill is $5.00 per capita; the annual loss of life from fire totals 15,000. The advantage of having fireproof construction is very great from an insurance and human life standpoint. Insurance companies give much reduced rates to fireproof construction.

By grounding metal construction, protection is also secured against lightning.

Style Roofing to Specify

THE architect and engineer have six popular styles of galvanized iron roofs from which to choose. They are:

- Standing Seam Roofing
- Pressed Standing Seam Roofing
- V Crimp Roofing
- Ribbed Seam Roofing
- Metal Tile and Shingles
- Corrugated Roofing (See Part Two)

Standing Seam

TIGHT JOB: This style affords the tightest job and is therefore particularly adapted for roofs of less than usual pitch. In fact, it may be used successfully where there is only a pitch of 2 in 12.

Roof water would have to back up and take the course indicated in A and B, Figure 1, to get through the standing seams and end locks respectively. Since these locks and seams are tightly swaged together, the result is practically a water-tight job.

DESCRIPTION: This roofing comes in rolls containing approximately one square of covering area when laid. Five resquared sheets, 26½″ wide and 122″ long, are joined end to end by a double cross lock which is power swaged (See enlarged seam in Figure 1). Cleats are supplied with the roofing at a small cost or may be made on the job.

The successive stages in laying this style of roofing are illustrated in Figure 1.

Nails are not driven through the sheets at any exposed point, but the sheets are entirely held in place by cleats which are nailed to closed sheathing and locked into the seams.

GAUGE: Furnished in 28 and 26 gauge—the latter (heavier) gauge being recommended where corrosive conditions are severe.

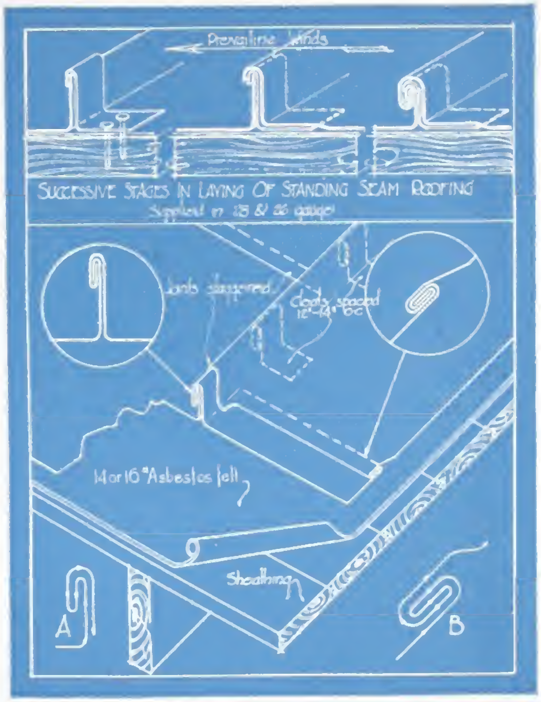


Figure One

COST OF LAYING: It costs more to lay Standing Seam Roofing than for the other styles mentioned above as there are more forming operations in turning the double lock on the standing seam.

Where two workmen would lay five or six squares of Standing Seam Roofing, they could lay about eight to ten squares of Pressed Standing Seam, or V Crimp Roofing. It is rather difficult to compare the labor cost of laying Standing Seam Roofing with the cost of laying Metal Shingles, but, if there is any difference, it is slightly in favor of Metal Shingles. While the cost of laying is greater, Standing Seam Roofing as stated, gives

the tightest job and should by all means be used where the pitch is, say, less than 4 in 12.

LAYING: (See Standard Practice in Laying—page 13).

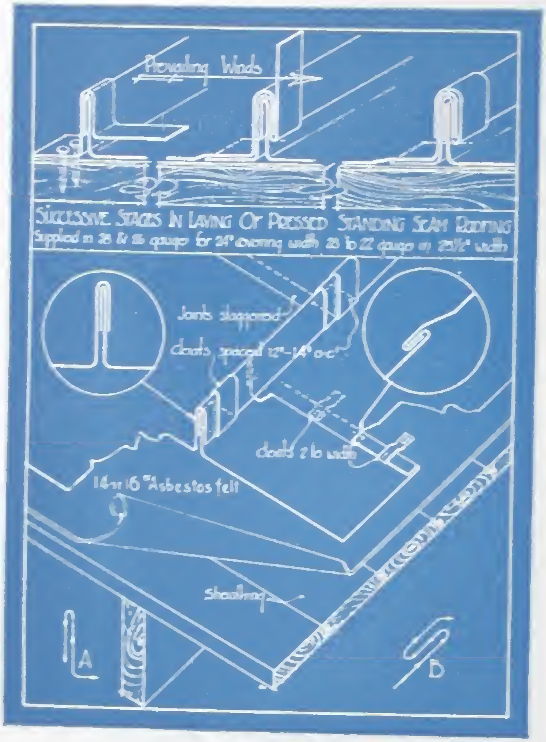


Figure Two

Pressed Standing Seam

DESCRIPTION: Pressed Standing Seam Roofing arrives on the job with the standing seams ready formed.

Cleats nailed to sheathing and locked into the side and end seams hold the sheets in place as for plain standing seam roofing.

SIZE AND GAUGE: Sheets having 24″ covering width and in foot lengths from 5′ to 12′ in 28 gauge to 22 gauge are supplied. Again the heavier gauges (smaller numbers) are recommended for severe corrosive conditions.

LAYING COST: (See discussion under this caption for Standing Seam Roofing—page 9).

CONSTRUCTION FEATURES: While this style does not offer as tight a feature as the Standing Seam Roofing; on the other hand, it is strongly recommended for roofs of 6 in 12 pitch or steeper. It will provide a tight job for roofs of this pitch at a less material cost, as well as reduced laying cost compared to the plain Standing Seam Roofing.

Figure 2 details the method of laying, and Figure 2, A and B, illustrate the course which backed up roof water would have to take to get through the standing seams and end seams respectively.

This roofing may be taken off and reapplied with simply the loss of the cleats. In this style two cleats are required for each end, or horizontal seam.

V Crimp Roofing

DESCRIPTION: V Crimp Roofing is available in either 2, 3, or 5 Crimps. The 2 V and 3 V roofing require a wood nailing strip (see Figure 3). The 5 V roofing offers a double V side lap, and while 26 gauge or lighter can be applied without wood nailing strips by nailing directly through the top of outer crimp, best practice requires a nailing strip as shown in figure 3. This style also offers a stiff sheet of more pleasing appearance, as the center crimp breaks up the flatness.

The course which backed up roof water would have to take in getting through the side seams of the 2 V and 3 V styles is shown in A, Figure 3; for the 5 V style, B, Figure 3.

PITCH: The 5 V Crimp style is adaptable for roofs having 6 in 12 pitch or steeper, and is comparable to the Pressed Standing Seam style as regards a tight job.

For roofs of steeper pitch than 6 in 12, 2 V and 3 V styles are recommended.

ON OPEN SHEATHING: The V Crimp styles may be used on open sheathing. When this is done, however, an end seam should be turned, and when it falls over an open space in the sheathing, a sheathing board should be inserted.

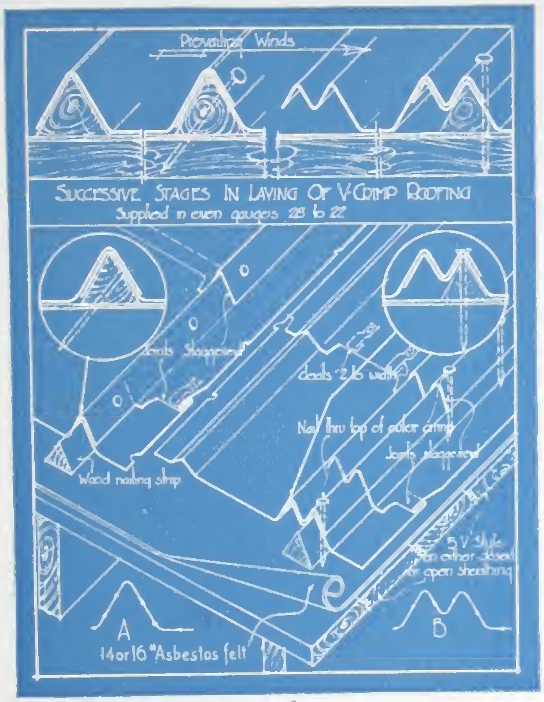


Figure Three

Size and Gauge: Stock sheets with 24″ covering width are available in even foot lengths from 5′ to 12′ and in even gauges from 28 to 22.

Wood Nailing Strips: Wood nailing strips for the 2 V, 3 V, and 5 V styles are supplied at a small additional cost.

Ribbed Seam Roofing

Description: This style roofing is formed by the sheet metal contractor over wood battens placed by carpenter. The stages in forming it over battens, as well as ridge, gable, and gutter finish, are detailed in Figure 4.

Pitch: Adaptable to roofs of steep pitch, this style should not be used on roofs pitched lower than 4 in 12, and preferably 6 in 12.

Size and Gauge: Since the sheet metal contractor forms this roofing from the flat galvanized iron sheets, the battens may be spaced any distance apart, with 48″ wide sheets as a limiting factor. It is perhaps best to space them the standard 24″ apart. Galvanized iron in 28, 26, or 24 gauge is used, the heavier gauge (smaller number) being specified where service conditions are severe. Heavier than 24 gauge metal would be difficult to work.

Cleats: Roofing sheets are secured to wood battens by cleats spaced 12″ to 14″ apart and alternating on top and side of batten (See Figure 4).

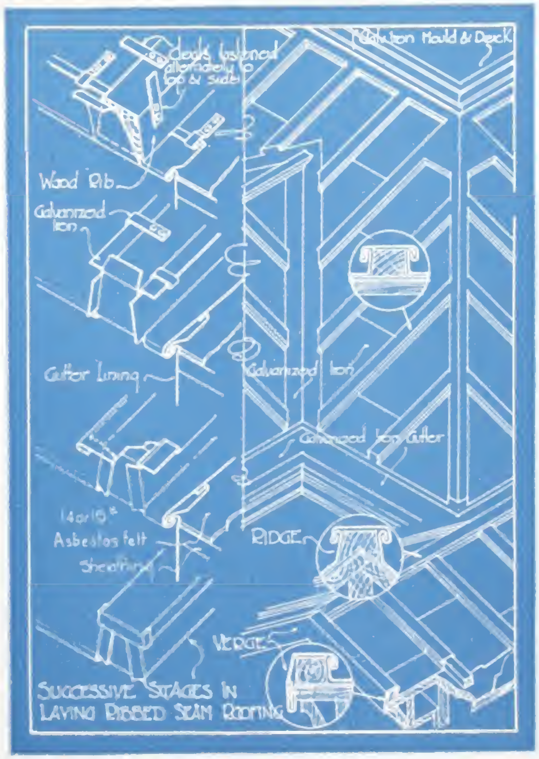


Figure Four

Wood Battens: Battens of cross section design, and spacing determined by architect, should be accurately spaced in straight lines and well nailed to sheathing.

Metal Tile and Shingles

Metal tile and shingles of proper gauge and tight locking feature offer a roofing more acceptable architecturally than perhaps any other metal type.

A metal roofing is almost a requirement for reducing the fire hazard in densely populated sections.

On all but the most pretentious residences, metal tile and shingles offer attractive roofing materials giving good protection at low cost.

A tile or shingle of the construction illustrated in Figure 5 offers a tight side-locking feature, and the 3 or 4 crimps at the end exclude backed up roof water from getting through the end lap. Metal tile or shingles are not recommended for roofs pitched less than 6 in 12.

Several large sheet metal manufacturers make tile and shingles of good construction and attractively painted in grays, browns, dark greens, and dark reds. They are readily available in Spanish tile, flat tile, slate, and special designs.

Metal tile and shingles are supplied by most manufacturers with a zinc coating which is applied by the hot-dip process after forming.

Though 28 gauge tile and shingles are available, it is strongly recommended that nothing lighter than 26 gauge be used.

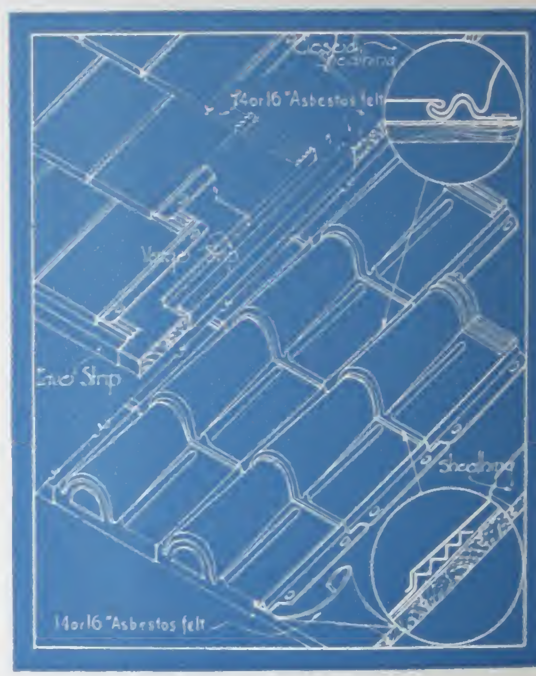


Figure Five

Porcelain enameled tile, which is porcelain enamel fused on pure iron, and which has many distinctive advantages, is also available.

Standard Practice In Laying Metal Roofing

PREPARATION OF SURFACE: The foregoing types of metal roofing may all be laid upon closed sheathing or over old wood shingles. Old shingles to be left on should be nailed down flat and securely and 14 or 16 pound asbestos felt laid between these shingles and the metal roofing. In all cases the surfaces should be free from projecting nails or other sharp objects.

PREVAILING WINDS: Side seams and side laps should, where possible, be to the lee side of prevailing winds, thus giving greatest protection against driving rains (See Figures 1, 2, and 3).

CLEATS: Horizontal, or end seams, should have two cleats. Cleats locked into side seams should be spaced 12″ to 14″ apart. It is not necessary to turn end of cleat back over nail head, as is the practice when using copper, since galvanized iron sheets are more impervious.

CONDENSATION: Metal roofings are good conductors of heat and cold; hence, moisture will more quickly condense than when cellular materials are used. This, however, is effectively cared for by the use of asbestos felt between the sheathing and roofing sheets, or by a tight job of tongue and groove sheathing.

COATING: The mills try to put the heaviest galvanized coating on the sheet that will withstand forming and seaming operations, as this zinc coating gives added protection to the base metal. Therefore, care should be taken by the roofer not to break or mar this coating, when handling and forming the sheets.

STRAIGHT LINES: Straight lines are secured in laying metal roofs of the Standing Seam and Corrugated types by laying from the eaves to the ridge of the roof rather than across the roof.

GAUGE TO USE: The use of the following gauges, for the various building parts shown, is recommended. The heavier gauge (smaller number) should be used where corrosive conditions are severe.

Suggested Gauges For Roofing and Roof Drainage Parts

Building Part	*Commercial and Public Buildings*	*Residential Buildings*
Roofing (Corrugated)	26-18	
(V-Crimp)	26-24	28-26
(Other Types)	26	28-26
Gutter and Eaves Trough	24	26-24
Conductor Pipe	24	26-24
Flashings	26-24	28-26
Valleys	24	26-24
Ridge Roll	26-24	28-26

PAINTING: It is best to allow galvanized sheets to weather six months or longer before painting. This is often undesirable and, in fact, impossible. Therefore, the following method is offered:

> Swab with acetic acid (vinegar). Follow this immediately by washing the sheets *thoroughly* with water. Allow to *thoroughly* dry, then paint.

It is also possible to use as priming coats, paints especially prepared for application to newly galvanized surfaces.

Ofttimes a mistake is made in trying to put on too heavy a coating which results in the paint flaking off much more than would be the case if a thinner coating had been given. Be sure the sheets are *thoroughly* dry before painting, as this is very often the cause for paint not holding to galvanized material.

A FEW DONT'S: Don't paint over damp galvanized sheets—be sure the surface is absolutely dry.

Don't make horizontal seams of roofing sheets continuous across the roof—they should be staggered or offset.

Don't place metals electro-negative to iron (copper, lead, tin, nickel, etc.) in contact with it.

Don't nail through sheets at exposed parts, especially near or in seams—use cleats.

Gutters, Downspouts, Elbows, and Shoes

FALL: Where it does not interfere with good design, gutters should have a *continuous* fall to drainage outlets.

The minimum recommended fall for hanging gutters is 1/8" in 12", and for built-in gutters or linings, 1/16" in 12".

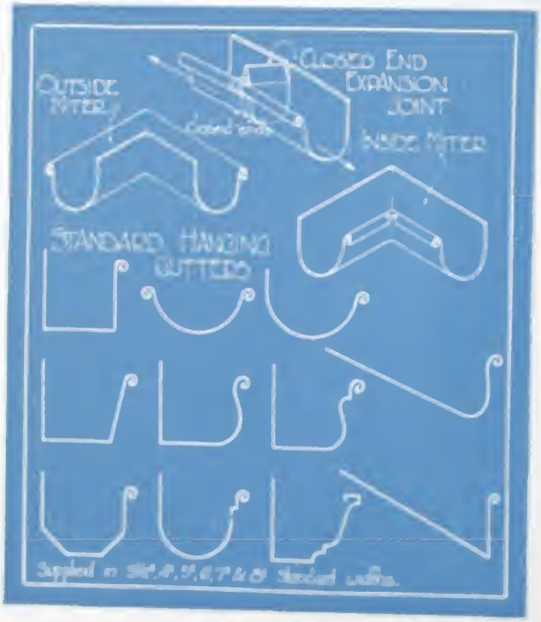


Figure Six

It is very important that "pockets" do not occur, and the architect should call for a water test in the sheet metal specifications to guard against pockets, or fall occurring in the wrong direction.

JOINTS: Gutter sections should be riveted and well soldered on both sides where it is possible to get at them. When this is not possible, the sections should be tightly locked and the seam well soldered. Laps and seams should be in the direction of drainage.

SHARP ANGLES: Sharp angles in the design of gutters should be avoided. One side of hanging gutter or gutter linings should slope outward to permit ice, which may become trapped, to expand or heave upward, and so avoid bursting the gutter.

EXPANSION AND CONTRACTION: Because of its relatively slight expansion, galvanized iron gutters and linings, formed continuously with locked and soldered joints (or when possible riveted and soldered joints) give a satisfactory job for runs of 50 feet or less. See "Expansion and Contraction," page 8. Where a run of over 50 feet is encountered, it is well to allow for expansion and contraction by making closed end sections (See top of Figure 6 for hanging gutters). A metal saddle prevents leakage where the ends butt together. The break should, of course, be made the high point of the flow line and be midway between drainage outlets.

The same idea can also be satisfactorily adapted to lined gutters.

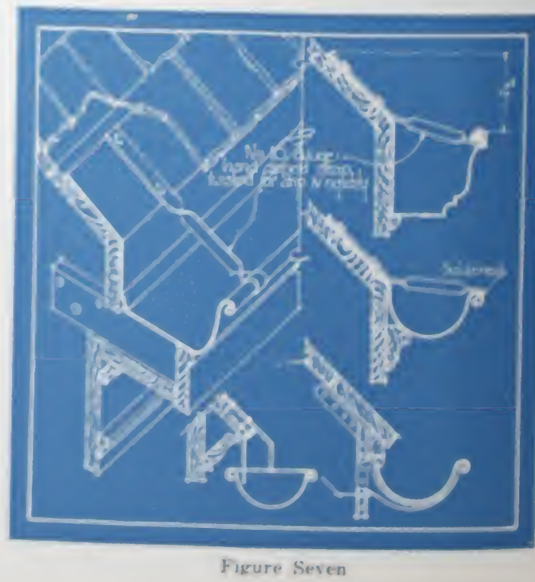


Figure Seven

PAINTING INSIDE: Best practice recommends painting inside of gutters and downspouts as an additional protection.

STRAPS AND HANGERS: Straps for hanging gutters should be about 1/8" thick, 1" wide and twisted (See Figure 7), to provide a drip and greater rigidity. The strap should be formed as shown to prevent the gutter being bent in by an outside force, such as a ladder leaned against it.

Straps for roof type gutters may be of lighter material, and while it is not so important to twist the strap to provide for drip, it is a more rigid construction and desirable for that reason.

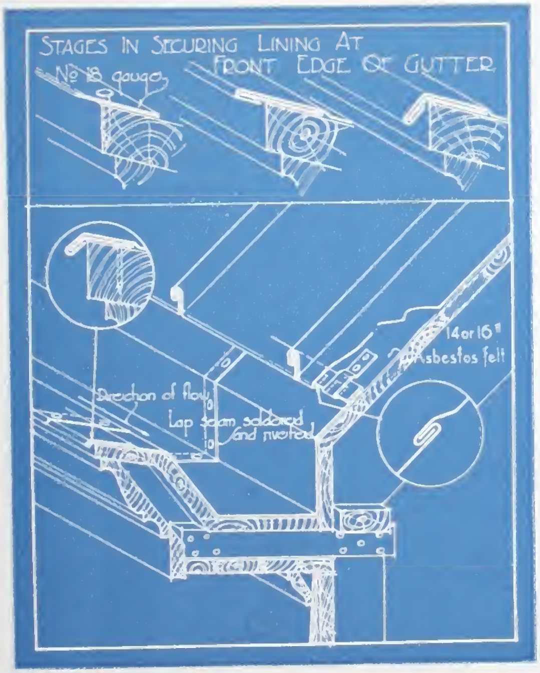


Figure Eight

The hanging gutter should extend 8 to 10 inches up the roof or to a point which would require water and melting snow to pile up to a height of about 4" above the edge of the gutter before seepage could get into the wood sheathing (See Fig. 7).

BOX GUTTERS: Figure 8 details a typical box gutter in connection with a standing seam galvanized iron roof.

Note that the galvanized iron gutter lining is locked to the roofing sheets and secured by metal cleats to the sheathing.

The roof edge of the gutter lining would be nailed direct to sheathing if other than a metal roof were used in connection with this gutter construction.

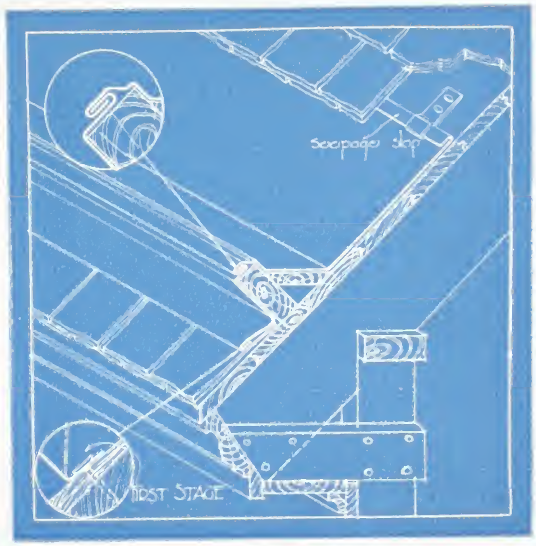


Figure Nine

The eave edge of the gutter lining is finished as shown by small drawings at top of Figure 8. This method provides a drip and at the same time does not obscure the design of the wood mold. If a 20 gauge or heavier strip is used and not more than a 3/4" projection given, there will be no danger of this edge being bent out of line by ladders or other objects being leaned against it.

POLE OR YANKEE GUTTER: In the pole type of lined gutter, Figure 9, it is important that the wood bed be firmly built with a continuous fall.

The two sections of the lining are secured as detailed at the two outer edges, brought together,

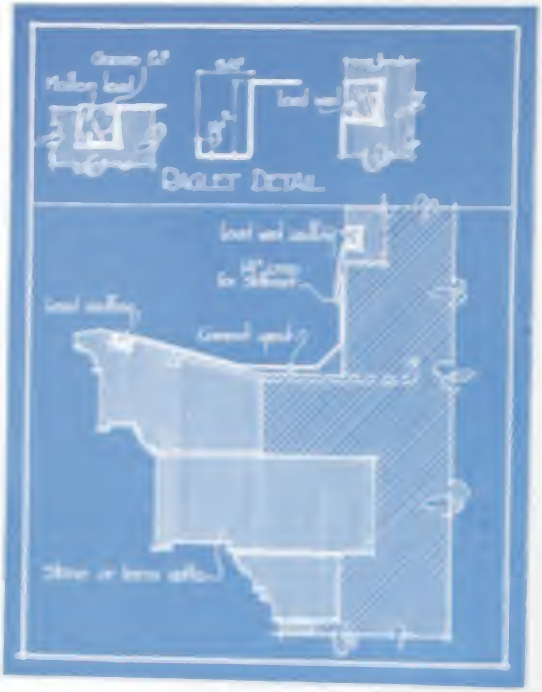


Figure Ten

hooked on top the pole and secured to it by cleats spaced about 14" apart.

Again the lining should extend 8" or 10" up the slope of the roof.

GUTTER LINING ON STONE OR TERRA COTTA BED: Figure 10 details the method of securing and flashing gutter linings on a stone or terra cotta bed.

Flashing grooves of about 1" square section are provided in the stone and terra cotta by other contractor. This groove should be narrower at face than back so that caulking will be keyed into the groove.

Molten lead and lead wool are used in caulking of horizontal and vertical surfaces respectively. A still better job is obtained by using lead plugs 24" o. c., in both the vertical and horizontal joints.

The bed is built up with a cement grout to secure fall to drainage outlets. A $\frac{1}{2}$" crimp in the counter flashing gives it a desirable stiffness and makes it lie close to the side walls.

DOWNSPOUTS, ELBOWS, AND SHOES: Downspouts, elbows, and shoes of the plain round, corrugated round, and square corrugated designs are standard in the industry in sizes noted in Figure 11. The octagon and polygon designs shown in Figure 11 are of special manufacture but are obtainable at a great many sheet metal jobbing houses. Elbows in 45 degree, 60 degree, 75 degree, and 90 degree angles are standard in the industry.

CONDUCTOR HOOKS: Round, corrugated, and toothed of the sickle variety; round, corrugated,

Figure Eleven

and square of the hinged type; round and square of the wired style, and the wire hanger, are standard in the industry.

All types are available with heavy drives for brick, stone, or concrete, or the lighter drives for wood in order to avoid splitting the wood. Hinged and wired types are available with or without drives attached.

Special or ornamental types of straps or hooks are also obtainable on order from most of the sheet metal supply manufacturers.

Valleys, Hips, and Ridges

BAFFLE RIB: Where a valley is formed by very steeply pitched, intersecting roofs, and, especially steep roofs of unequal pitch, a baffle rib (See A, Figure 12) is a good thing. It prevents water coming off the steeper pitched roof from riding up the other roof with danger of seepage into the sheathing. Their function is illustrated at D, Figure 12.

SEEPAGE STOP: A seepage stop formed as detailed at A, Figure 12, is desirable when used in connection with a slate or shingle roof. Cleats are always to be used, though particularly in connection with metal roofs, in securing roof and roof drainage parts to sheathing (See B, Figure 12). A plain valley without seepage stop or baffle rib is detailed at C, Figure 12.

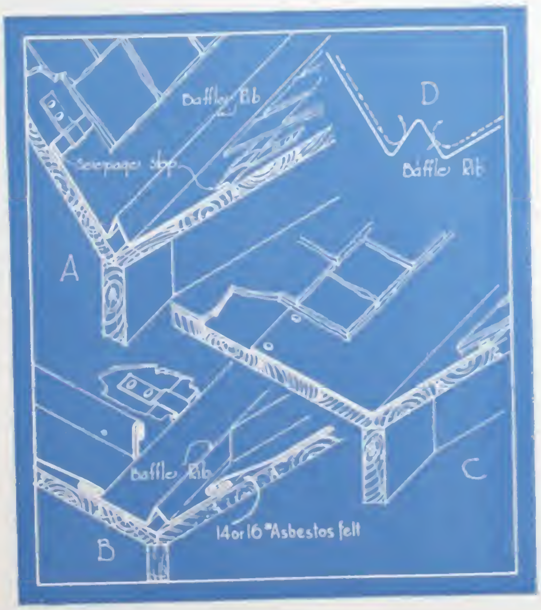


Figure Twelve

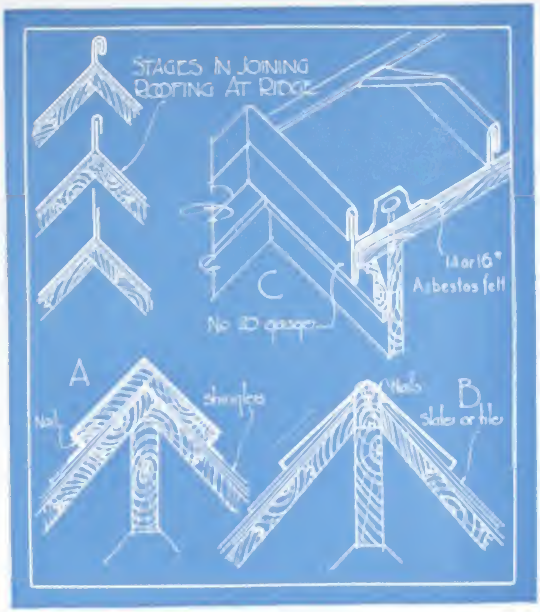


Figure Thirteen

CLOSED VALLEY: A closed valley is flashed, as shown in Figure 16. The galvanized iron flashing may be nailed to sheathing without use of cleats.

TILE AND SLATE ROOFS: For tile and slate covered roofs, B, Figure 13, details a ridge capping structurally and architecturally good. Not lighter than 20 gauge galvanized iron should be used, and this capping should be bent to a more acute angle than the roof so that when drawn to the ridge board with nails or screws, the outer crimp edge of the apron will lie close to the roof. Not less than a 6" apron should be used. Nail or screw heads should be soldered to capping.

WOOD SHINGLED ROOFS: A, Figure 13, shows a ridge capping of satisfactory construction. The nail heads should be soldered to the capping both in this capping and the one detailed at B, Figure 13.

Ridge and hips for standing seam metal roofings are finished as detailed at C, Figure 13.

STANDING SEAM METAL ROOF: The sheets are left 1¾″ long on one side and this projection over the ridge turned vertically. A 1½″ projection is left on the other side and turned vertically. The former is then turned ¼″ down on the latter and then another turn of ½″ given. This gives a 1″ standing seam along the ridge and hips and, besides making a water-tight joint, expansion and contraction is provided for.

The gable end of a metal roof is given a trim and well constructed finish as at C, Figure 13.

Flashings

GENERAL: Locks and seams should be turned away from flow of water. Flashings should extend high enough up vertical surfaces to exclude water and standing snow seeping through.

Nails should never be driven through flashings at points which will be exposed. This applies to roofings sheets and other sheet metal parts.

BRICK VERTICAL SURFACE: The method detailed in A, Figure 14, for locking the base flashing pieces around a corner is typical for flashing any vertical surface. Note that the lock is turned away from the flow of the roof water. When used in connection with a shingle type roof, the base flashing should be built in with the shingles as here shown. On a metal roof of standing seam type or on a composition roof this base flashing is a continuous piece.

Figure Fourteen

The flashing should extend at least 6" up the vertical wall and the counter flashing lap to within 1½" of the bottom.

A ½" crimp is made at the bottom of each piece of the stepped counter flashing to stiffen it and make it lie tightly to the wall. The counter flashing pieces are built into the brick joints about 1½" and wedged with lead or rolled metal pieces. Brick joints are pointed with cement mortar.

STUCCO VERTICAL SURFACE: Flashing a stuccoed vertical surface, as detailed in B, Figure 18, results in a satisfactory job. The counter flashing is formed to provide a stop for the stucco. B 1, Figure 18, details an alternate method which is also good. The base and counter flashings should not extend too far up under the stucco as this would separate the lower edge from being firmly secured to the sheathing. Two or three inches should ordinarily be sufficient.

SHINGLED VERTICAL SURFACE: The flashing is simply carried about 8" up the side wall and nailed to the sheathing (See A, Figure 18) for a shingled vertical surface. A metal roof would be flashed against a shingled wall by locking the flashing to the roofing sheets, as at C, Figure 16, and nailing it to the sheathing 8" to 10" up the side wall.

CHIMNEY THROUGH SLOPE OF ROOF: Where a chimney intersects but one slope of a roof, a saddle covered with a base flashing, as in Figure 15, is built. This connects to the rest of the base flashing by the same kind of lock illustrated at A, Figure 14, the lock at each corner being turned away from the flow of roof water. A, Figure 15, details the method of joining metal roofing sheets to the base flashing around an interseting wall through slope of roof.

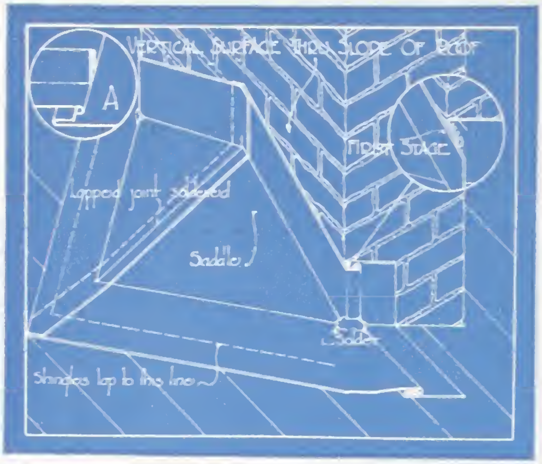


Figure Fifteen

Figure Sixteen

Recessed Dormer Window: Flashing of a recessed dormer window is shown in detail in Figure 16. Seams at A and C, Figure 16, should be soldered to secure the best job and keep melting snows from seeping through.

The flashing piece at B is nailed to the sheathing before the standing seam decking is locked to it.

Note that the flashing at C is extended to the back line of the frame to form a pan.

D, Figure 16, details the flashing of a stuccoed vertical surface—the counter flashing making a stucco stop. This is discussed in detail under "Stucco Vertical Surface." An alternate method is shown at B1, Figure 18.

The flashing should not extend so far above lower edge of stucco as to endanger securing bonding to the wall.

Flashing of window cap, ridge and closed valley are shown at F, G, and H, respectively.

Pediments: Flashing of curved and triangular pediments is shown in Figure 17. A, Figure 17, details a method of flashing which should give satisfaction.

The galvanized iron deck covering is given a 1" flange at the back, and the front is bent under upon itself but not tightly closed. This lock is slipped from the front over an 18 gauge galvanized iron strip nailed to the top of the pediment and projecting the front edge of crown mould ½". This seam is then slightly bent to form a drip.

The flashing extending up the wall may be made from one piece when possible and the bottom cut

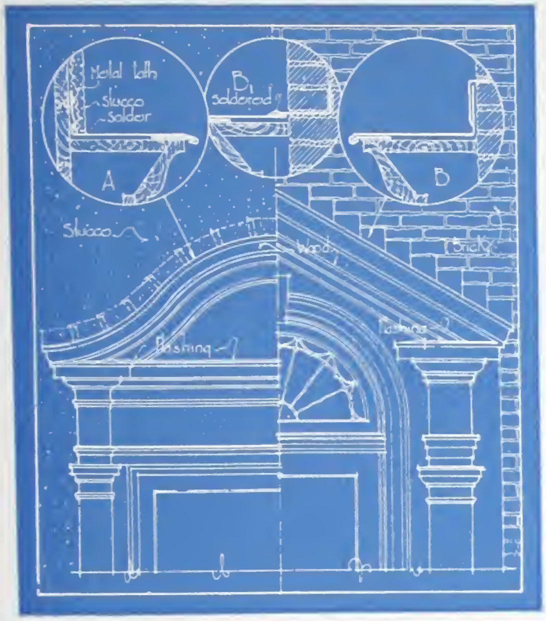


Figure Seventeen

to the curve of the pediment and lapped over the 1″ flange which is turned up on the deck covering. This lapped joint is to be thoroughly soldered. All parts of pediment as shown should be flashed.

If the wall flashing is made in several pieces, they should lap each other on the sides at least 2″ or 3″. The wall flashing should not extend more than 2″ or 3″ up the wall, as a further extension might endanger secure bonding of the lower section of stuccoed wall.

Another method of flashing a curved pediment is to use soft lead, as it may be conformed from one piece to a curved intersection if it is not too sharp a curve.

The flashing of a triangular pediment is shown at B and B1, Figure 17. Flashing as at B1 is, of course, difficult and costly and is only used where the sight of stepped flashing is considered objectionable. This method requires that the mason cut the face brick to the line of the pediment and build in the flashing pieces as detailed in the drawing.

Window Sill in a Stucco Wall: Discoloration of stucco walls about a window is quite common. This may be largely, if not entirely, eliminated by the method shown at C, Figure 18.

The wood sill is cut off flush with the outside window casing or hanging stile and a metal ear nailed at each end of the sill to form a drip for dirty water. The projection of this ear need not be more than ¼″ beyond the wood all around.

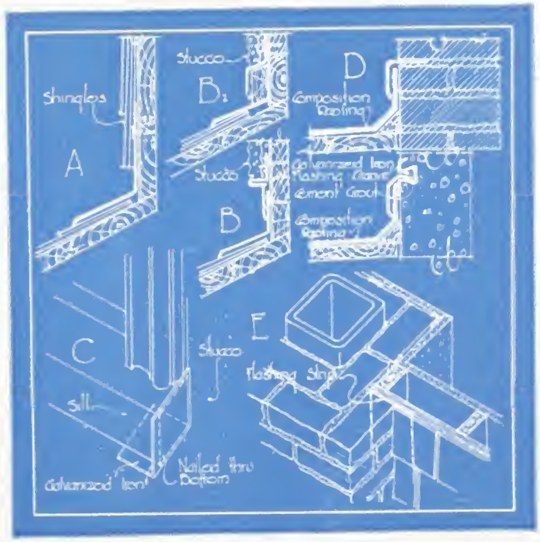
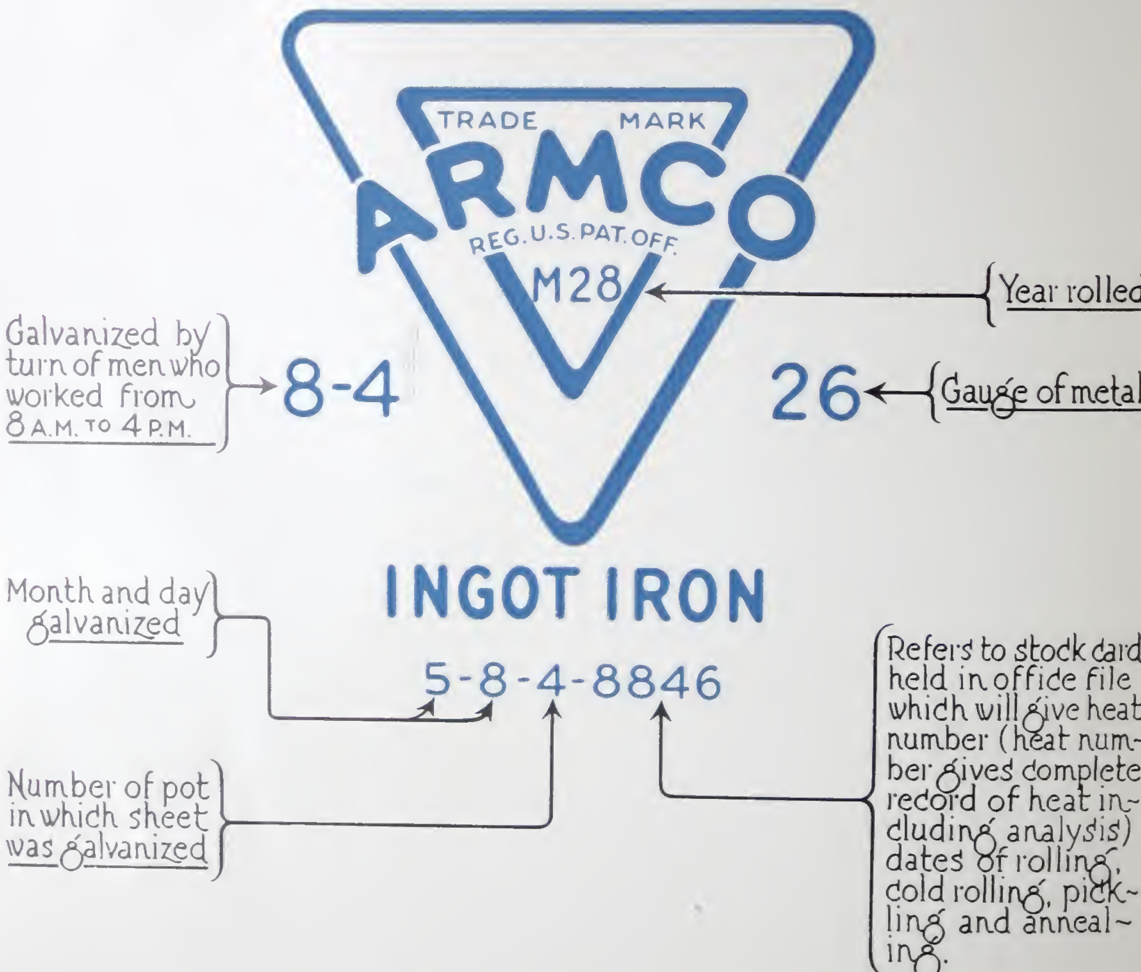


Figure Eighteen

Chimney Cutting Through Shingle or Clapboard Walls: A good method for making a tight job where a chimney cuts through a shingle or clapboard wall is as detailed at D, Figure 18.

Composition Roofing: Flashing of composition roofings intersected by masonry walls is detailed at D, Figure 18. It is important that corners be built up to support the roofing and protect it against being punctured.

Protection Against Substitution



This is the trade mark of ARMCO Ingot Iron, the purest iron made. Every sheet of pure iron is marked with the blue triangle. On jobs where rust-resisting ARMCO Ingot Iron of a definite gauge is specified, care should be taken to guard against substitution of inferior grades or lighter gauges. The gauge is shown at the right of the triangle.

All ARMCO Ingot Iron sheet metal work should bear at least a portion of the triangle trade mark shown above, for it is placed at intervals diagonally across the sheet. If ARMCO Ingot Iron is specified and the triangle is not in evidence, either inside or outside, it is an indication that the specifications have not been fulfilled.

Suggestions for Sheet Metal Specifications

(Where Galvanized Iron Is To Be Used)

Note: The ARMCO organization maintains an Architects' Sheet Metal Service Bureau which will gladly work out with architects the sheet metal problems that may arise.

General

1. GALVANIZED MATERIAL: The sheet metal work indicated on drawings and later noted in these specifications shall be of galvanized ARMCO Ingot Iron of specified Standard gauge—manufacturer's brand and gauge number to show plainly on each sheet or on each ready formed product. All straps, hangers, and other devices for securing sheet metal work shall be of galvanized iron.

2. MEASUREMENTS: All measurements necessary to this work shall be verified at the job by the sheet metal contractor and any discrepancies between existing work and contemplated work reported promptly to the architect.

3. CLEANING: The sheet metal contractor shall see that the job is clean and in first class shape to receive his work and, if necessary, shall report to the architect any unsatisfactory condition.

Likewise, he shall leave the job free of all unworked material, rubbish, etc., of his own making.

General Workmanship

4. GALVANIZED COATING: Care shall be taken to avoid breaking and unnecessarily scarring the galvanized coating while forming and applying the galvanized iron sheets. Hammering on the sheets shall be done with a wood mallet.

SOLDER: Where indicated, best grade, 50-50 solder shall be used and well sweated into seams and locks with a hot iron.

NAILS: Barbed and dipped galvanized nails shall be used to secure sheet metal work, except where otherwise indicated.

Note to Architect: To prevent nails from drawing out of the wood, either due to drying out of the wood or to the action of wind, it is necessary that the nail should penetrate entirely through the roofing board.

The diameter of the nail should be proportioned to the softness of the roofing board. Where hard, firm wood is used a hard temper roofing nail, well barbed near the point and of a diameter of one-eighth of an inch, generally furnishes reliable anchorage if used in sufficient quantity. Where soft, spongy or sappy roofing boards are used, nails at least five-thirty-seconds of an inch in diameter and well barbed near the point should be used. The apparent slight difference in diameter makes a very considerable difference in the holding power of the nail.

DETAILS: Except where otherwise called for, the various sheet metal parts shall be constructed and applied as detailed in "Galvanized Iron for Roofs and Roof Drainage," 1928 edition by The American Rolling Mill Company, Middletown, Ohio.

Metal Roofing

5. PREPARATION OF SURFACE AND PAPER: All sheathing shall be laid solid and the nails shall be flush or set, as a preparation for the metal roofs. All surfaces to receive the metal roofs shall be swept clean by this contractor who shall then lay a 14lb. per 100 sq. ft. asbestos felt, free from tar or acid. Same to be laid with 2" side lap.

6. MATERIAL: Cover all roofs and elsewhere as indicated on drawings with (a) *Standing Seam* — (b) *Pressed Standing Seam* — (c) *2, 3, or 5 V Crimp* — (d) *Metal Shingle* — (e) *Ribbed Seam* —Roofing of standard gauge galvanized iron as specified.

Note to Architect: Standing Seam, Pressed Standing Seam, and Ribbed Seam Roofings may be 26 or 28 gauge; 2, 3, or 5 V Crimp styles are supplied in 22, 24, 26, and 28 gauge; Metal Shingles are supplied in 28 gauge. Heavier gauge (smaller number) should be used where corrosive conditions are severe. Standing Seam Roofing is adaptable for decks having as much as ½ in 12 pitch.

7. STANDING SEAM ROOFING: Sheets shall be applied to have 1" standing side seams. Horizontal

seams shall be double seamed and staggered. Seams to be tightly swaged together.

Standing seams where possible shall be turned to the lee side of prevailing winds.

Roofing sheets shall be secured to sheathing by galvanized iron cleats throughout (same gauge as roof sheets) spaced not farther than 14″ apart and locked into side seams and nailed to sheathing.

8. Pressed Standing Seam Roofing: Sheets to be secured to sheathing by galvanized iron cleats (same gauge as roof cleats) with a maximum spacing of 14″ and locked into side and end seams and nailed to sheathing. Horizontal joints shall be staggered. Seams to be tightly swaged together. Standing seams where possible shall be turned to lee side of prevailing winds.

9. V Crimp Roofing: Sheets shall be secured by (a) *nailing every 10″ to 12″ through lap side of crimp, through wood nailing strip, and into sheathing* — (b) *nailing every 10″ to 12″ through top of outer crimp.*

Note to Architect: Wood nailing strips used only with 2 V and 3 V styles.

Horizontal seams shall be locked and secured to sheathing by two galvanized iron cleats (same gauge as roof sheets). End or horizontal seams to be offset. Side lap shall, where possible, be made to lee side of prevailing winds.

10. Ribbed Seam Roofing: Sheet metal contractor shall verify alignment and equidistant spacing of battens placed by carpenter. He shall see that they are well secured to sheathing with nail heads flush or set.

Note to Architect: Clause should be inserted in carpenter specifications for battens or ribs as follows: On roofs where indicated in drawings, place battens or ribs of design detailed. They shall be firmly nailed to sheathing, special care being taken to space them equidistant from eave to ridge, and to secure good alignment. Nail heads to be flush or set.

The sheets shall be (a) *27* — (b) *24* — (c) *21* inches wide by commercial lengths. They shall be applied to battens by cleats spaced not more than 12″ apart and alternating top and side of battens.

Special care shall be exercised to produce a water-tight job at points where battens intersect ridges, hips, valleys, and gutters, and, if necessary to secure a tight job, this contractor shall solder laps and seams at aforementioned points.

Note to Architect: Width of sheet required is determined by subtracting width of one batten from c to c spacing and adding twice the height of the batten and plus one inch for lock.

11. Metal Shingles: Sheet metal contractor shall furnish and apply 26 gauge metal shingles of (a) *Spanish tile* — (b) *flat tile* — (c) *slate design.*

Standard starting shingles, ridge capping, finial pieces, etc., suitable to the style of shingle specified, shall be used.

12. Snow Guards: Provide snow guards as detailed and approved by the architect.

Gutters

13. Hanging Gutters: Hanging gutters of (a) *26* — (b) *24* gauge galvanized iron shall be placed as shown on drawings and firmly installed using (a) *dipped galvanized and twisted straps of 1/8″ thickness. Lining to extend up roof 8″ or 10″ or to a point at least 4 vertical inches above front edge of gutter and to be nailed every 12″ to roof sheathing* — (b) *galvanized adjustable hangers.* Gutters shall be (a) *given a continuous fall to drainage points* — (b) *level and this contractor shall give them a water test in the presence of the architect to make sure that they do not drain in wrong direction or contain pockets.* Gutter sections shall be riveted and well soldered on both sides. No less than five rivets to each joint shall be used.

Runs of more than 50 feet shall be broken by butting closed end sections together and connecting with a metal saddle.

Note to Architect: See top of Figure 6 in this manual.

Edges of circular holes cut in gutter bottoms for receiving thimble connections to conductor pipes shall be slightly flanged downward so that soldered connection will not cause water to lie at these points.

14. GUTTER LININGS ON WOOD BED: Sheet metal contractor shall see that carpenters have built a firm bed of continuous fall to drainage points.

Gutter lining sections shall be riveted and soldered both sides of 1″ lap where possible to do this. Where this is impossible, the sections shall be tightly locked and well soldered and secured by cleats locked into seam and nailed to wood bed.

15. GUTTER LININGS ON STONE OR TERRA COTTA BED: Sheet metal contractor shall build a bed of continuous fall to drainage points with a Portland cement grout of not leaner than 1—4 mix. White Atlas cement shall be used in connection with stone.

The lining shall be of (a) *26* — (b) *24* gauge and joints shall be riveted and well soldered with edges caulked into flashing grooves with (a) *molten lead and lead wool* — (b) *molten lead and lead plugs and lead wool and lead plugs.*

16. PAINTING INSIDE: Inside of gutters and lining shall have a protective coating of paint completely covering inside surfaces.

Conductor Pipe, Elbows, and Devices

17. SIZES AND DESIGN: Conductors and elbows shall be galvanized iron, (a) *plain round* — (b) *corrugated round* — (c) *square corrugated* — (d) *octagon* — (e) *polygon* — of (a) *28* — (b) *26* — (c) *24* gauge and of sizes marked on drawings.

18. PAINTING INSIDE: Inside of downspouts and elbows shall have a protective coating of paint completely covering inside surfaces.

19. HEADS AND STRAPS: Conductors shall have ornamental heads with capping, and straps, all according to detail drawings.

20. WIRE BASKETS: Galvanized wire baskets shall be provided over all openings into gutters.

21. SECURING TO WALL: Conductor pipe shall be secured to wall by (a) *galvanized iron hooks* — (b) *ornamental galvanized iron straps, as detailed on drawings, secured to wood surfaces with galvanized nails, and to masonry with expansion sleeve screws.* Conductor pipe shall be soldered to this support to prevent its slipping.

22. SHOES AND TILE DRAIN: Where drawings indicate surface drainage, galvanized iron shoes shall be provided. Conductor pipe shall be cemented into tile drain pipe where sub-surface drainage is called for.

Valleys, Hips, and Ridges

23. CLOSED VALLEYS: Closed valleys shall be flashed in one continuous locked and soldered piece extending at least 10″ on both slopes of intersection.

24. OPEN VALLEYS: Open valleys shall be provided with (a) *baffle rib and seepage stop* — (b) *seepage stop* — (c) *plain flashing* and valley secured to sheathing with (a) *barbed and dipped galvanized nails* — (b) *cleats spaced every 10″ to 12″.*

Note to Architect: Cleats are used to secure valleys only in connection with metal roofings.

25. BOSTON HIPS: Boston hips shall be flashed with metal pieces built in with shingle or slate courses and in such manner as not to be exposed to the weather.

26. RIDGES AND HIPS ON SLATE OR TILE ROOFS: Ridges and hips shall be capped as detailed.

27. RIDGES AND HIPS ON SHINGLE ROOFS: They shall be capped as detailed.

Flashings

28. GENERAL: Flash all intersections of roofs with vertical surfaces of every kind and all openings through roof, such as skylights, bulkheads, etc., with galvanized iron as specified. The base and counter flashing method shall be generally used except as otherwise specified.

29. BASE FLASHINGS: Base flashings shall extend at least 6″ up vertical surfaces unless otherwise specified and shall extend at least 6″ out on roofs or decks.

Where vertical surface intersects slope of a shingle or slate roof, the base flashing shall be built into the shingle or slate courses by the roofer.

30. Base Flashings on Metal Roofs: They shall be locked to metal roofs and secured to sheathing by cleats spaced not more than 14″ apart.

31. Counter Flashings: Counter flashings shall extend at least 6″ above intersection of roof and shall lap over base flashing at least 4 inches. Lower edge of both continuous and stepped counter flashings shall reach within 1″ of roof and shall be given a ½″ crimp to cause it to lie tightly against the wall.

32. Counter Flashing on Wood Surfaces: They shall extend up under slate, shingles, or clapboard at least 6″ and be securely nailed to side sheathing.

33. Counter Flashing of Masonry Surfaces: They shall extend into masonry joint 1½″ and shall be secured by rolled metal wedges. Sloping intersections shall have stepped counter flashing pieces lapping each other on the side at least 2″.

34. Counter Flashing of Stuccoed Surfaces: 1. They shall form a (a) *¾″* — (b) *⅞″* — (c) *1″* stucco stop 3″ up from roof intersection and shall extend 3″ above this. They shall be secured by rolled metal wedges to masonry backing or nailed to sheathing if stucco is over wood framing. 2. They shall be formed over a (a) ¾″ —(b) ⅞″ — (c) 1″ baseboard and extend 3″ above board and nailed to side sheathing.

35. Counter Flashing of Concrete Surfaces: A sheet metal raggle block form shall be tacked to wood forms by masonry contractor as directed by this contractor before concrete is poured. This raggle shall be at least 6″ above roof intersection, and counter flashing with hooked edge shall be caulked into this raggle with plastic cement.

36. Counter Flashing in Connection With Composition Roofs: The various plys of paper shall be brought up on side walls at least 6″ high at all points and thoroughly mopped each layer. Counter flash over this with galvanized iron.

37. Saddle or Cricket Flashing: Saddles or crickets shall be constructed behind all chimneys or other vertical surfaces where slope of roof meets same in such manner as to divert water away from same.

These saddles shall be covered with galvanized iron.

38. Window and Door Flashing: The heads and sills of all exterior doors and windows shall be flashed, and a metal pan placed under (a) *all sills* — (b) *sills of dormers* — (c) *door to balcony.*

Where sills are adjacent to stuccoed walls, metal ears shall be placed as detailed.

Note to Architect: Drawing for this is detailed at C. Figure 18.

Skylights

39. Skylights: Furnish and erect skylights where indicated. Same shall be substantially constructed of (a) *22* — (b) *24* — (c) *26* — (d) *28* gauge galvanized iron well riveted and soldered and securely fastened in place.

Skylights to be provided with suitable condensation gutters so as to properly conduct condensation water to the outside. All ribs and ridges of skylight frames to be reinforced with iron bars.

This contractor shall furnish and glaze skylights with (a) *wire glass ¼″ thick* — (b) *double strength AA American glass. These skylights shall be equipped with two heavy wire screens; one set over and one under skylight and large enough to cover entire opening. Screen to be constructed with heavy iron frames and stiffening bars, 1″ diagonal mesh screening and iron supports all to be given two good coats of paint by this contractor before being set.*

At each end of skylight the contractor shall construct curved pipe ventilator of__________inches diameter and provided with weather cap, etc., complete, all of (a) *26* — (b) *24* — (c) *22* — (d) *20* gauge galvanized iron as specified.

Scuttle

40. Scuttle: The carpenter will construct a door for scuttle opening in roof, but this contractor shall cover the top and sides with (a) *24* — (b) *26* — (c) *28* gauge galvanized iron.

Specification Memoranda

Nomenclature

TRUSS: A truss is a framed structure in which the members are so arranged and fastened at their ends that external loads applied at the joints of the truss will cause only direct stresses in the members. In its simplest form, a truss is a triangle or a combination of triangles.

MEMBER: A member or piece of structure is a single unit of the structure, as a beam, a column, or a web member of a truss.

TRANSVERSE BENT: A transverse bent consists of a truss supported at the ends on columns and braced against longitudinal movement by knee braces attached to the lower chord of the truss and to the columns.

PURLIN: A beam that rests on the top chords of roof trusses and supports the sheathing that carries the roof covering or supports the roof covering directly, or supports rafters.

BEAM: A beam is a structural member which is ordinarily subject to bending and is usually a horizontal member carrying vertical loads. In a framed floor, beams are members upon which rest directly the floor plank, slab, or arch.

SUB-PURLIN: A secondary system of purlins that rests on the rafters and spaced so as to support the tile or slate covering directly without the use of sheathing.

SHEATHING: A covering of boards or reinforced concrete that is carried on the purlins or rafters to furnish a support for the roof covering.

GIRT: A beam that is fastened to the columns to support the side covering either directly or to support the side sheathing.

TIE: A tie is a structural member which tends to lengthen under stress.

DEAD LOAD: Dead load is the weight of a structure itself plus any permanent loads. In design, the weight of the structure must be assumed; and the design corrected later if the assumed weight is very much in error. Brick and concrete construction have the largest dead load relative to the total load.

LIVE LOAD: Live load is any moving or variable load which may come upon the structure—as, for example, the weight of people or merchandise on a floor, or the weight of snow and the pressure of wind on a roof. The total load, or dead load plus live load, must be used in design. In addition the dynamic effect or impact of the live load must often be considered.

MONITOR VENTILATOR: A framework at the top of the roof that carries fixed or movable louvres or sash in the clerestory.

CLERESTORY: The clear opening in the side framework of a monitor ventilator of a building, also the clear opening on the side of a building.

LOUVRES: Slats made of metal or wood which are placed in the clerestory of a monitor ventilator to keep out the storm. Louvres may be fixed or movable.

PANEL: The distance between two joints in a roof truss or the distance between purlins.

BAY: The distance between two trusses or transverse bents.

PITCH: The pitch of a truss is the center height of the truss divided by the span where the truss is symmetrical about the center line. (See Drawing No. 11, Page 42).

SPAN: The span of a building is the distance between the main columns, parallel with the truss.

STRUT: A beam that is fastened between columns or trusses which serves as a tie or brace.

LEANTO: A shed roof building against the side of the main building.

SQUARE: A square is equal to 100 sq. ft.

Working Data

GENERAL: Corrugated iron sheets are used very extensively for industrial and mill buildings because of their great strength and the rigidity they impart to the structure.

They are usually laid directly upon roof purlins and siding girts and are held in place by iron straps, which encircle the girt and are riveted to the corrugated sheets; or the sheets are held by clips and bolts which are spaced about 12″ apart.

DESCRIPTION: The 2½″ corrugated galvanized iron sheet is the one most used on industrial buildings, although sheets are also supplied by the mills in 1¼″, 3″, and 5″ corrugations, and in either the black (unprotected), or galvanized grade. Corrugations of 1¼″, 2½″ (actual 2-2/3″), 3″, and 5″ width have a depth of ⅜″, ½″, 9/16″, and ⅞″ respectively.

The 2½″ and 3″ corrugated sheets are made to cover 24″ when lapped. The 1¼″ corrugated sheet covers 23⅞″ for siding and 25⅛″ for roofing when lapped, and the 5″ corrugated sheet covers 25″ when lapped.

Stock sizes are made in lengths of 5, 6, 7, 8, 9, and 10 feet. Sheets less than 5′ long or more than 10′ long, or sheets cut to fractional foot lengths, or sheets cut to the pitch of gable ends may be obtained. A nominal extra charge is made for sheets of other than stock size.

Orders should specify whether sheets are for roofing or siding, as the 2½″ corrugated sheets are made 27½″ wide to lap one and one-half corrugations for roofing, and 26″ wide to lap one corrugation for siding. Also, where possible, order sheets to span two or more purlin or girt spaces; that is, two or more panels.

GAUGE: 2½″ corrugated sheets are supplied in even gauges from 10 to 28 standard gauge. Corrugated sheets, 5″ and 3″, are supplied in 12 to 28 even gauges. Corrugated sheets, 1¼″, are supplied in 20 to 28 even gauges.

Best practice calls for 20 or 22 gauge roofing sheets, and 22 or 24 gauge sheets for siding.

SIDE AND END LAPS: A one and one-half corrugation side lap for roofing and one corrugation side lap for siding should be given. Sheets should be given an end lap of 4″ for roofs of steeper pitch than 6 in 12; 6″ end lap for roofs pitched 5 in 12 to 6 in 12; 8″ end lap for roofs pitched 4 in 12 to 5 in 12; for roofs of lower pitch than 4 in 12, an 8″ end lap, laid in plastic cement, allowing about two pounds of cement to each 100 square feet, should be given.

METHOD OF APPLICATION: In laying corrugated roofing and siding, the lap should be made to the lee side of prevailing winds to give greatest protection against driving rains.

Special care should be taken that the projecting edges of sheets at the eaves and gable ends are well secured; otherwise, the wind may loosen the sheets at these points.

The roof sheets are laid in courses from eave to ridge of roof in order to best maintain straight lines. The several approved methods for securing roofing sheets to either steel or wood purlins are illustrated in Drawing No. 1, Page 32.

In securing sheets to wood framing, barbed and dipped galvanized nails are used and driven through the top of the corrugation in the case of roofing, and in the valley of the corrugation in the case of siding. Nails should be driven only through sides and ends of the sheets.

FLASHING AT EAVES AND GABLES: In the lower right hand corner of Drawing No. 1 is shown a method for flashing at the eaves. Flashing of gable ends and parapet walls is detailed in Drawing No. 2, Page 33.

CORRUGATED IRON SIDING: Application of corrugated iron siding to steel girts is shown in Drawing No. 3, Page 34. Side laps should be riveted about every 12″ using closing rivets. Specifications should state that care is to be exercised by steel erector in bucking rivets, not to break and mar the galvanized coating. A 4″ end lap and one corru-

gation side lap is standard for applying corrugated iron siding.

In securing corrugated iron siding to wood girts and studding, barbed and dipped galvanized nails are used and driven through the valleys of the corrugation. They should be nailed about 8″ apart at the ends and about every 12″ through the side lap where backed with wood studding.

Corners of buildings may be made weather-tight by using an angle capping or by bending the siding sheets around the corner and making about three corrugation laps (See Drawing No. 3, Page 34).

Gutters: Valley gutters and hanging gutters are constructed as detailed in Drawing No. 4, Page 35. Care should be taken that gutters are given a continuous fall to drainage points and that no pockets occur at any point in the flow line.

Louvres: Construction of louvres in the sides of the clerestory of a building is detailed in Drawing No. 5, Page 36. The method of flashing the inner section of the roof with the wall of the clerestory is also shown.

Door Openings: Construction of side and head jambs, and track for sliding doors in connection with corrugated siding is detailed in Drawing No. 6, Page 37.

Estimates and Lists: Drawings Nos. 7 and 8, Pages 38 and 39, illustrate the method of dimensioning between bays, girts, purlins, and at windows for estimating the number and sizes of corrugated sheets required. Attention is again called to the fact that on this list those sheets which are for roofing should be so indicated.

Straps, Clinch Rivets, Clips, Hook Bolts, and Nails: Straps are made of No. 18 standard gauge iron $^{3}/_{4}$″ wide. These straps pass around the purlins and are riveted to the sheets with about 3/16″ diameter rivets $^{3}/_{8}$″ long. Or bolts may be used, though this is not often done.

In estimating quantities of straps and rivets, figure one strap of the required length and two rivets or bolts for each lineal foot of girt or purlin to which these corrugated sheets are to be fastened and add 20% to the number of rivets for waste and 10% to the straps or bolts.

Rivets of the size above mentioned are called five pound rivets; that is, 1000 rivets will weigh five pounds.

Straps are shipped in bundles which weigh fifty pounds, and each bundle contains forty straps ten feet long, or 400 lineal feet. The straps are cut to the desired length, in the field, to suit the job.

Clinch rivets or nails are made from No. 9 or No. 10 Birmingham gauge wire, which clinches around the edge of the angle iron or channel. They are made in inch lengths from 5″ to 13″. Order two rivets or nails to each lineal foot of purlin or girt to which the corrugated sheets are to be fastened, and add 10% for waste. Care should be used in punching the holes in the corrugated sheet for clinch rivets or nails to get them in the top of corrugations, and to avoid making the hole unnecessarily large.

Hook bolts, as the name implies, are bolts hooked at one end and threaded at the other. The bolt hooks over the purlin or girt and the corrugated sheets are drawn firmly down on these members by tightening the nut on the threaded end. A lead and a tinned washer are used with hook bolts, between the galvanized sheet and the nut on the bolt. The lead washer is placed next to the sheet and the tinned washer goes over it as a protection from bearing pressure of the nut.

Clips with bolts are also used for fastening corrugated sheets to steel purlins or girts. Clips are made of No. 16 gauge iron 1½″ wide, about 2½″ long, and are slightly crimped at one end to go over the flange of the purlins. Clips are also made of cast iron. The bolts are common stove bolts about 3/16″ in diameter and 1″ in length. The clips and bolts should not be used except in special cases where the regular fastenings cannot be easily applied.

In cases where flashing, cornice work, or several thicknesses of metal are to be fastened at one point, rivets or bolts other than standard lengths mentioned will be needed. Closing rivets ½″ long

and bolts 1½″ long will usually answer in these cases.

Barbed and dipped galvanized nails of 8 dwt, are used to secure corrugated sheets to wood framing. Lead washers are used with the nails. Nails with washers are spaced about 12″ apart for both end and side laps, with 20% added for waste. The weight of 96—8 d nails is one pound, and it requires about ½ pound of nails and about ¼ pound of washers to properly lay one square of corrugated roofing or siding. Lead-headed and mushroom-headed, barbed and dipped galvanized iron nails are also frequently used, and each has recommending features. These types do not require washers.

Ridge Roll: Ridge Roll most commonly used is made from 24 gauge flat galvanized sheets, and has a 2½″ roll and 6″ apron. This size is known as 18″ girth. The length most commonly used is 96″. Allowance should be made for 3″ end laps.

Ridge Roll is made with either plain or corrugated aprons, but the plain apron ridge roll is recommended, as the outer ¾″ of the apron can be peened into the corrugations of the roofing sheets and a much tighter job secured than by depending upon the corrugated apron matching the corrugations of the sheets coming up from both slopes of the roof.

Flashings: Flashings are used where the roof changes slope, around chimneys and openings in the roof, under louvres, and over windows and doors. They should be of sufficient dimensions and so arranged that at least three inches vertical height is obtained between the upper edge of the flashings and the end or side of the corrugated iron roofing at the break in slope, or opening through the roof. It is even better and safer to figure 6″ for the vertical height.

Vertical and horizontal seams of all flashings should be closely riveted and should be soldered to make a good tight job. Flashings are made from flat sheets of the same gauge as siding sheets, and can be made in lengths up to 120″. Corrugated flashings may be obtained, but plain flashings are recommended as the outer edges may be peened into the corrugations, resulting in a much tighter job.

Purlin Spacings: Empirical tests have shown that corrugated sheet iron, ⅝″ corrugation depth and .035″ thick (approximately No. 21 standard gauge) spanning 6 feet, begins to give a permanent deflection with a load of 30 pounds per square foot, and that under a load of 60 pounds, the sheet fails. The distance between centers of purlins should, therefore, never exceed 6′, and should preferably be less than this. Purlins are seldom spaced over 4′9″ center to center in current good practice.

Having determined the gauge of galvanized iron to be used for roofing, or, having determined purlin spacings, the following formula will give the maximum purlin spacings and necessary gauge of galvanized iron respectively to be used:

$$W = \frac{25{,}600\ bdt}{l} \text{ where}$$

W = Total allowable uniform load, in pounds
b = Curvilinear width of sheet, in inches
(b equals 1.075 x covering width)
l = Unsupported length of sheet, in inches
t = Thickness of sheet, in inches
d = Depth of corrugations, in inches
f = Allowable fiber stress in pounds per square inch

The building up of the formula is as follows:

$$W = \frac{8fS}{l} = \frac{8f}{l} \times \frac{4bdt}{15} = \frac{32fcdt}{15\,l}$$

Then:

$$\text{for } f = 12{,}000,\quad W = \frac{25{,}600\ bdt}{l}$$

Drawing No. 9, Page 40, shows a graphic solution of this formula. For example: Assuming that a combined dead wind, and snow load of 40 pounds per square foot, this chart shows that the use of No. 16 gauge corrugated iron will permit purlins to be safely spaced 5′ apart, or with No. 18 gauge iron, 4-4/10′ apart, with No. 20 gauge iron 3-9/10′ apart, etc. Or, that a purlin spacing of 3′ requires No. 24 gauge iron, of 3½′ requires No. 20 gauge iron, of 4′ requires No. 18 gauge iron, etc.

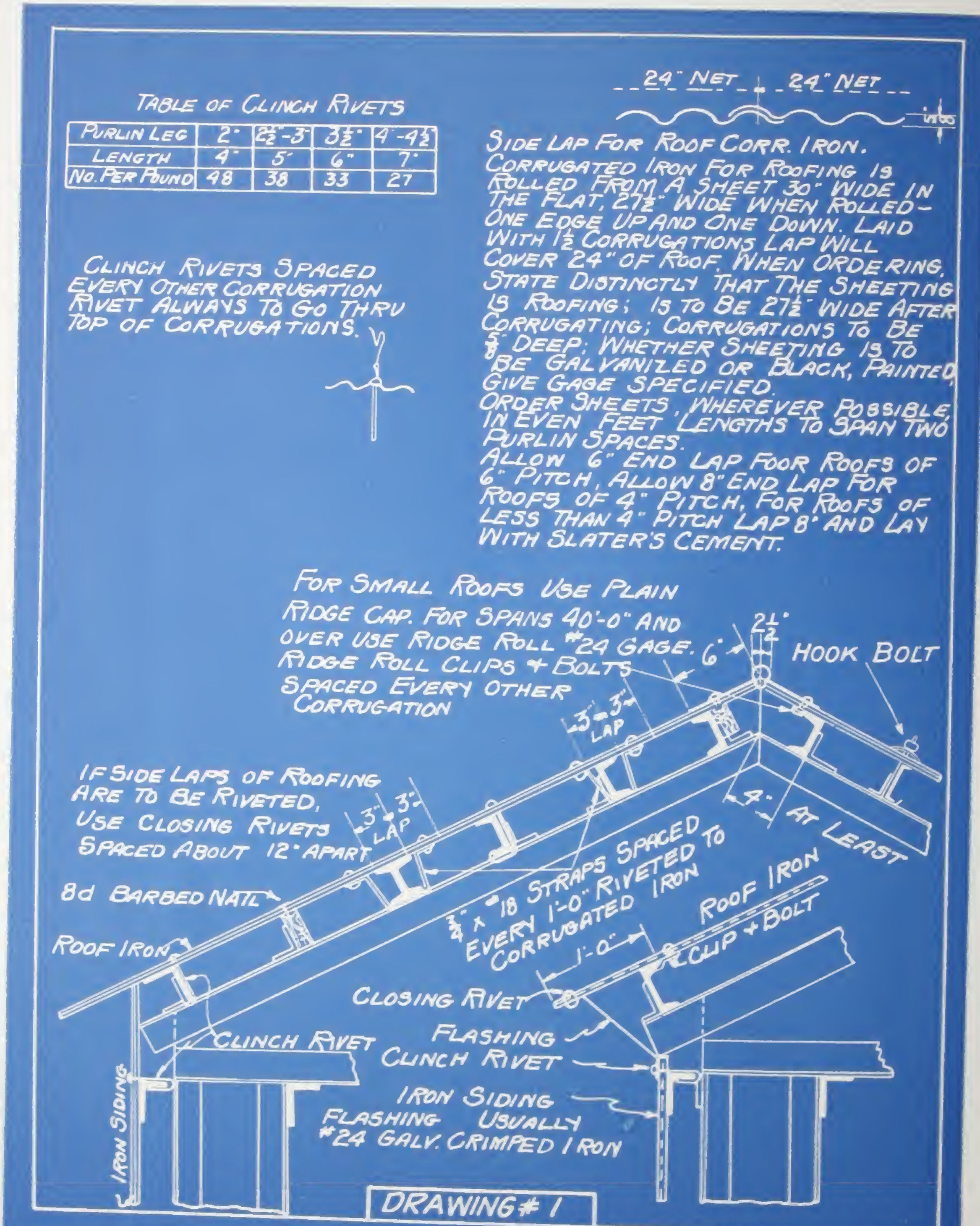
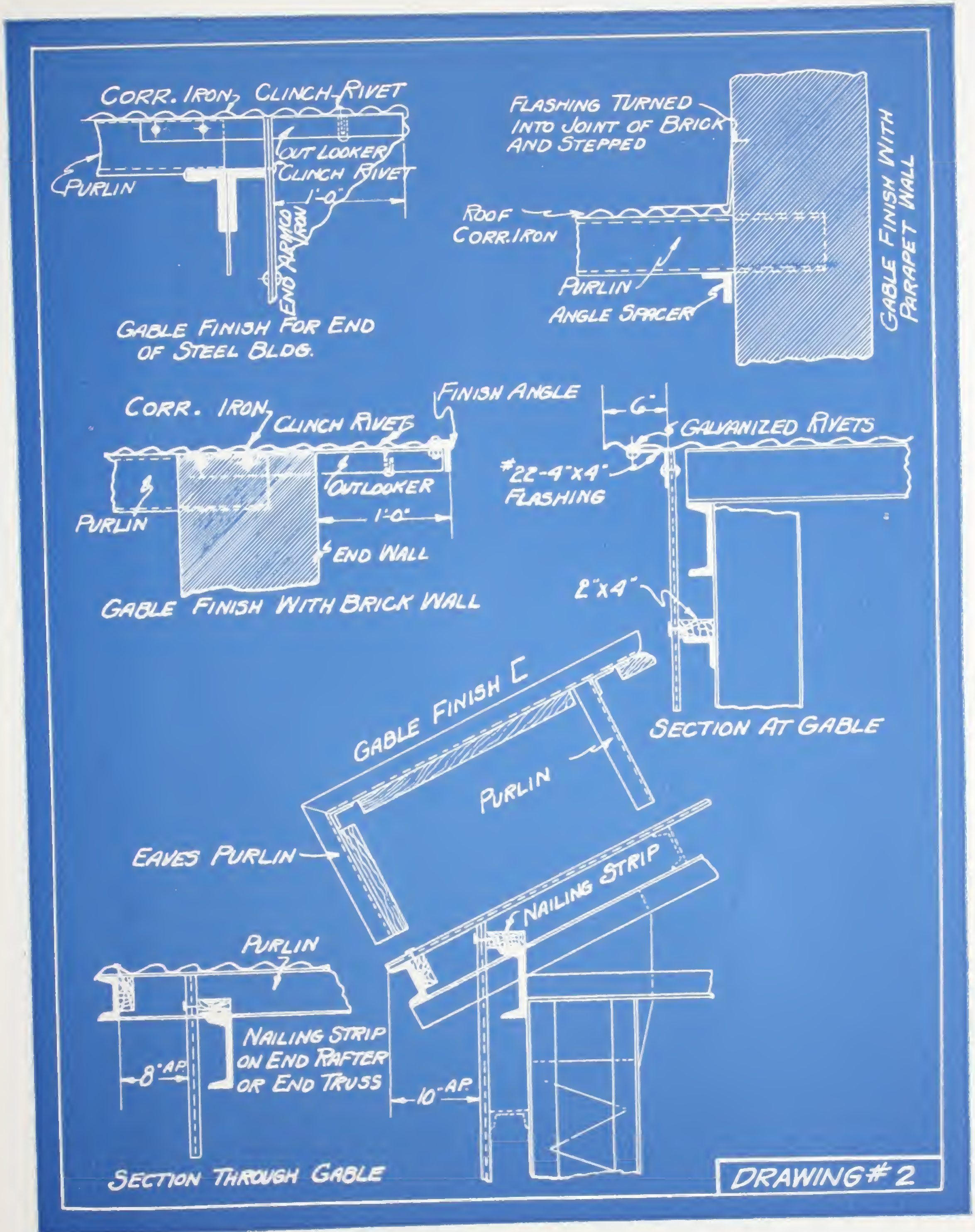
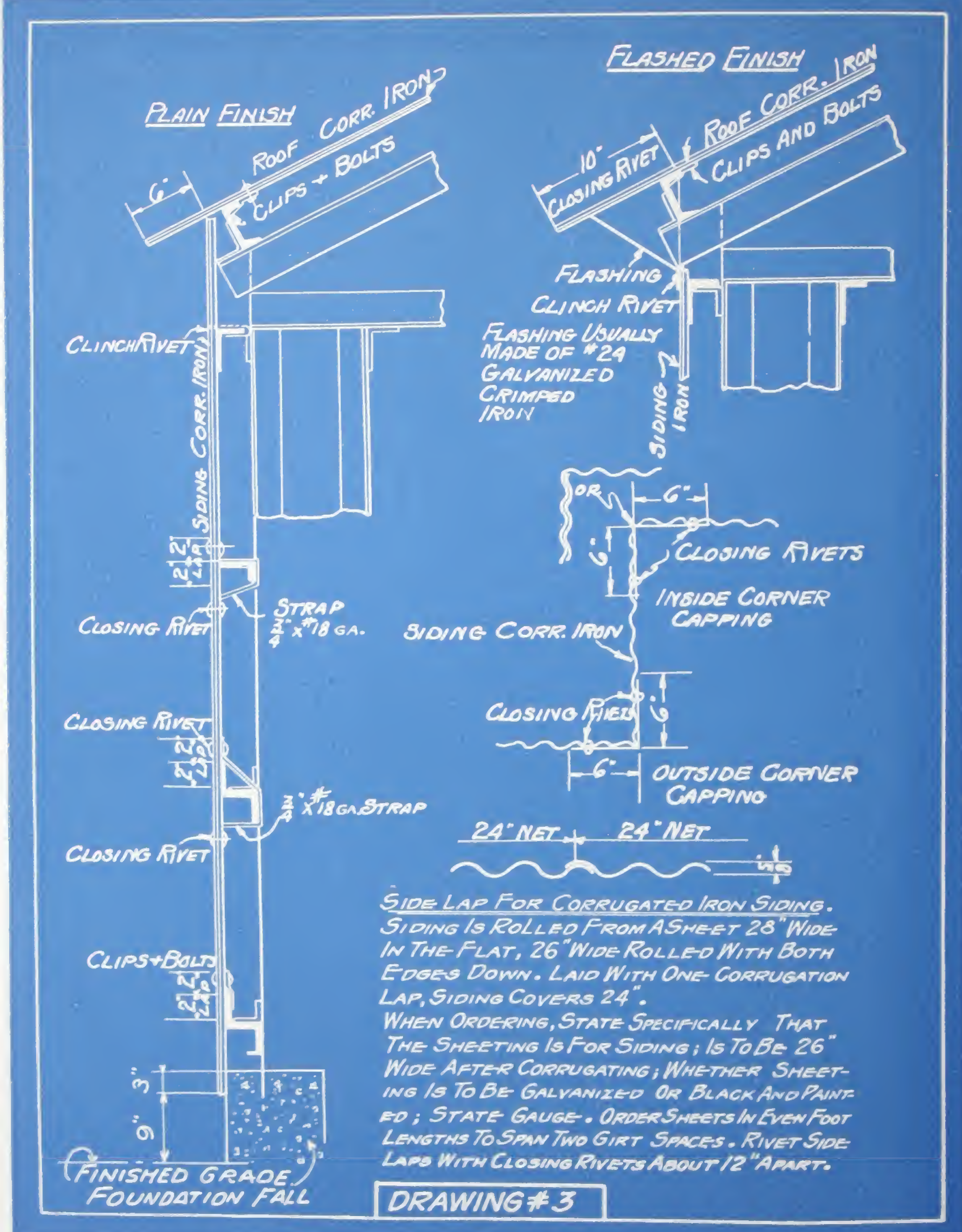
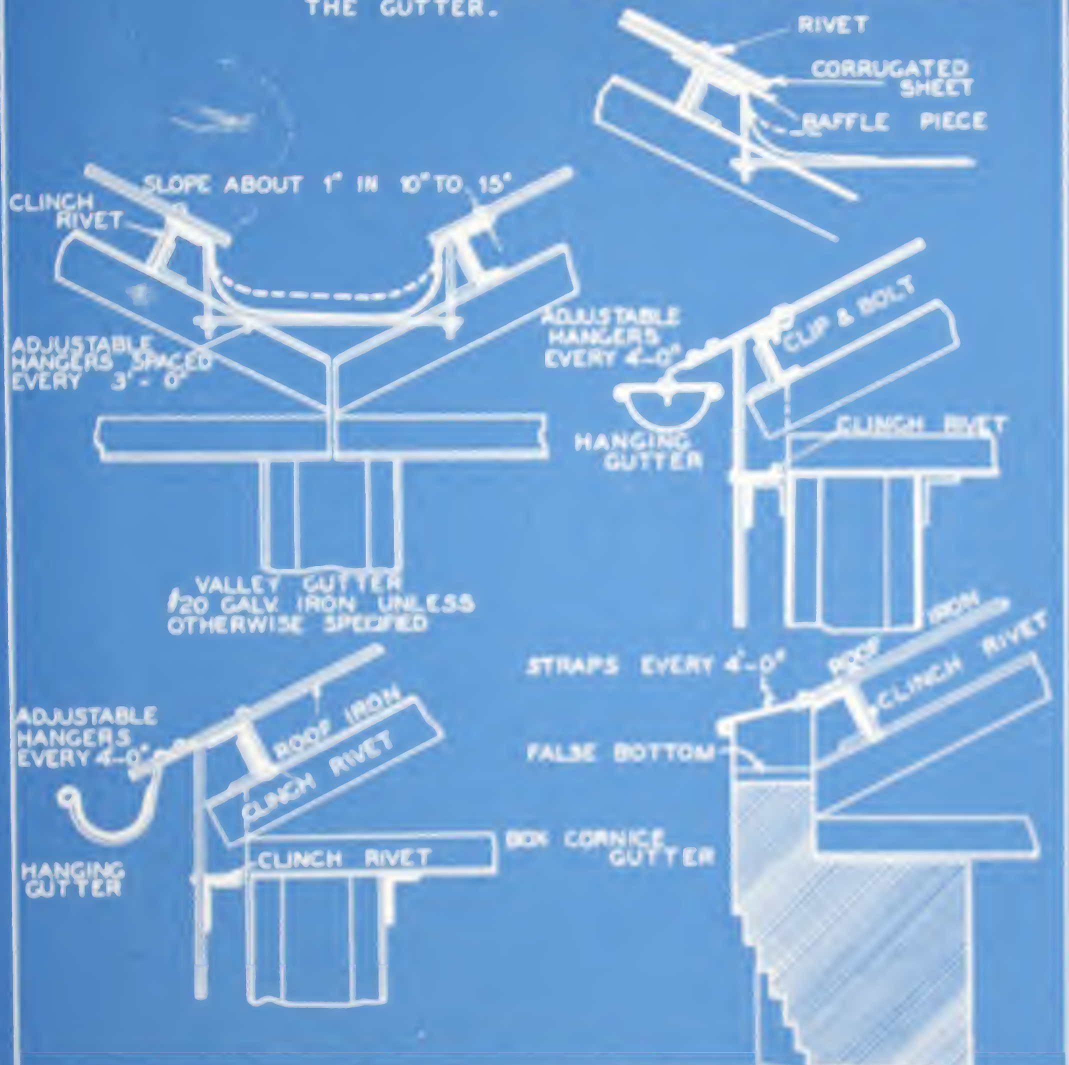


TABLE OF CLINCH RIVETS
PURLIN LEG | 2" | 2½"-3" | 3½" | 4"-4½"
LENGTH | 4" | 5" | 6" | 7"
NO. PER POUND | 48 | 38 | 33 | 27
24" NET
24" NET
SIDE LAP FOR ROOF CORR. IRON.
CORRUGATED IRON FOR ROOFING IS ROLLED FROM A SHEET 30" WIDE IN THE FLAT, 27½" WIDE WHEN ROLLED– ONE EDGE UP AND ONE DOWN. LAID WITH 1½ CORRUGATIONS LAP WILL COVER 24" OF ROOF. WHEN ORDERING, STATE DISTINCTLY THAT THE SHEETING IS ROOFING; IS TO BE 27½" WIDE AFTER CORRUGATING; CORRUGATIONS TO BE ⅝" DEEP; WHETHER SHEETING IS TO BE GALVANIZED OR BLACK, PAINTED, GIVE GAGE SPECIFIED.
ORDER SHEETS, WHEREVER POSSIBLE, IN EVEN FEET LENGTHS TO SPAN TWO PURLIN SPACES.
ALLOW 6" END LAP FOOR ROOFS OF 6" PITCH, ALLOW 8" END LAP FOR ROOFS OF 4" PITCH, FOR ROOFS OF LESS THAN 4" PITCH LAP 8" AND LAY WITH SLATER'S CEMENT.
CLINCH RIVETS SPACED EVERY OTHER CORRUGATION RIVET ALWAYS TO GO THRU TOP OF CORRUGATIONS.
FOR SMALL ROOFS USE PLAIN RIDGE CAP. FOR SPANS 40'-0" AND OVER USE RIDGE ROLL #24 GAGE. RIDGE ROLL CLIPS + BOLTS SPACED EVERY OTHER CORRUGATION
6"
2½"
HOOK BOLT
3"-3" LAP
IF SIDE LAPS OF ROOFING ARE TO BE RIVETED, USE CLOSING RIVETS SPACED ABOUT 12" APART
3"-3" LAP
4" AT LEAST
8d BARBED NAIL
ROOF IRON
¾" x #18 STRAPS SPACED EVERY 1'-0" RIVETED TO CORRUGATED IRON
ROOF IRON
1'-0"
CLIP + BOLT
CLOSING RIVET
CLINCH RIVET
FLASHING
CLINCH RIVET
IRON SIDING
IRON SIDING
FLASHING USUALLY #24 GALV. CRIMPED IRON
DRAWING # 1


CORR. IRON
CLINCH RIVET
OUT LOOKER
CLINCH RIVET
1'-0"
PURLIN
END ARMCO IRON
GABLE FINISH FOR END OF STEEL BLDG.
FLASHING TURNED INTO JOINT OF BRICK AND STEPPED
ROOF CORR. IRON
PURLIN
ANGLE SPACER
GABLE FINISH WITH PARAPET WALL
CORR. IRON
CLINCH RIVETS
FINISH ANGLE
OUTLOOKER
PURLIN
1'-0"
END WALL
GABLE FINISH WITH BRICK WALL
6"
GALVANIZED RIVETS
#22-4"x4" FLASHING
2"x4"
SECTION AT GABLE
GABLE FINISH C
PURLIN
EAVES PURLIN
NAILING STRIP
PURLIN
NAILING STRIP ON END RAFTER OR END TRUSS
8" AP.
10" AP.
SECTION THROUGH GABLE
DRAWING # 2


PLAIN FINISH
ROOF CORR. IRON
CLIPS + BOLTS
6"
CLINCH RIVET
SIDING CORR. IRON
2" 2" LAP
CLOSING RIVET
STRAP 3/4" x #18 GA.
CLOSING RIVET
2" 2" LAP
3/4" x #18 GA. STRAP
CLOSING RIVET
CLIPS + BOLTS
2" 2" LAP
3"
9"
FINISHED GRADE
FOUNDATION FALL
FLASHED FINISH
ROOF CORR. IRON
CLIPS AND BOLTS
10"
CLOSING RIVET
FLASHING
CLINCH RIVET
FLASHING USUALLY MADE OF #24 GALVANIZED CRIMPED IRON
SIDING IRON
OR
6"
CLOSING RIVETS
INSIDE CORNER CAPPING
SIDING CORR. IRON
CLOSING RIVETS
6"
OUTSIDE CORNER CAPPING
24" NET
24" NET
SIDE LAP FOR CORRUGATED IRON SIDING.
SIDING IS ROLLED FROM A SHEET 28" WIDE IN THE FLAT, 26" WIDE ROLLED WITH BOTH EDGES DOWN. LAID WITH ONE CORRUGATION LAP, SIDING COVERS 24".
WHEN ORDERING, STATE SPECIFICALLY THAT THE SHEETING IS FOR SIDING; IS TO BE 26" WIDE AFTER CORRUGATING; WHETHER SHEETING IS TO BE GALVANIZED OR BLACK AND PAINTED; STATE GAUGE. ORDER SHEETS IN EVEN FOOT LENGTHS TO SPAN TWO GIRT SPACES. RIVET SIDE LAPS WITH CLOSING RIVETS ABOUT 12" APART.
DRAWING #3

FOR A TIGHT JOB ON SUCH AS COTTON WAREHOUSE ETC. THE VALLEY GUTTER CONSTRUCTION DETAILED IN UPPER RIGHT HAND CORNER, DRAWING #4, WILL PROVE SIMPLE AND EFFECTIVE IN KEEPING DRIVING RAINS FROM FORCING AN ENTRANCE BETWEEN THE CORRUGATION OF THE ROOFING SHEET AND THE FLAT APRON OF THE GUTTER.

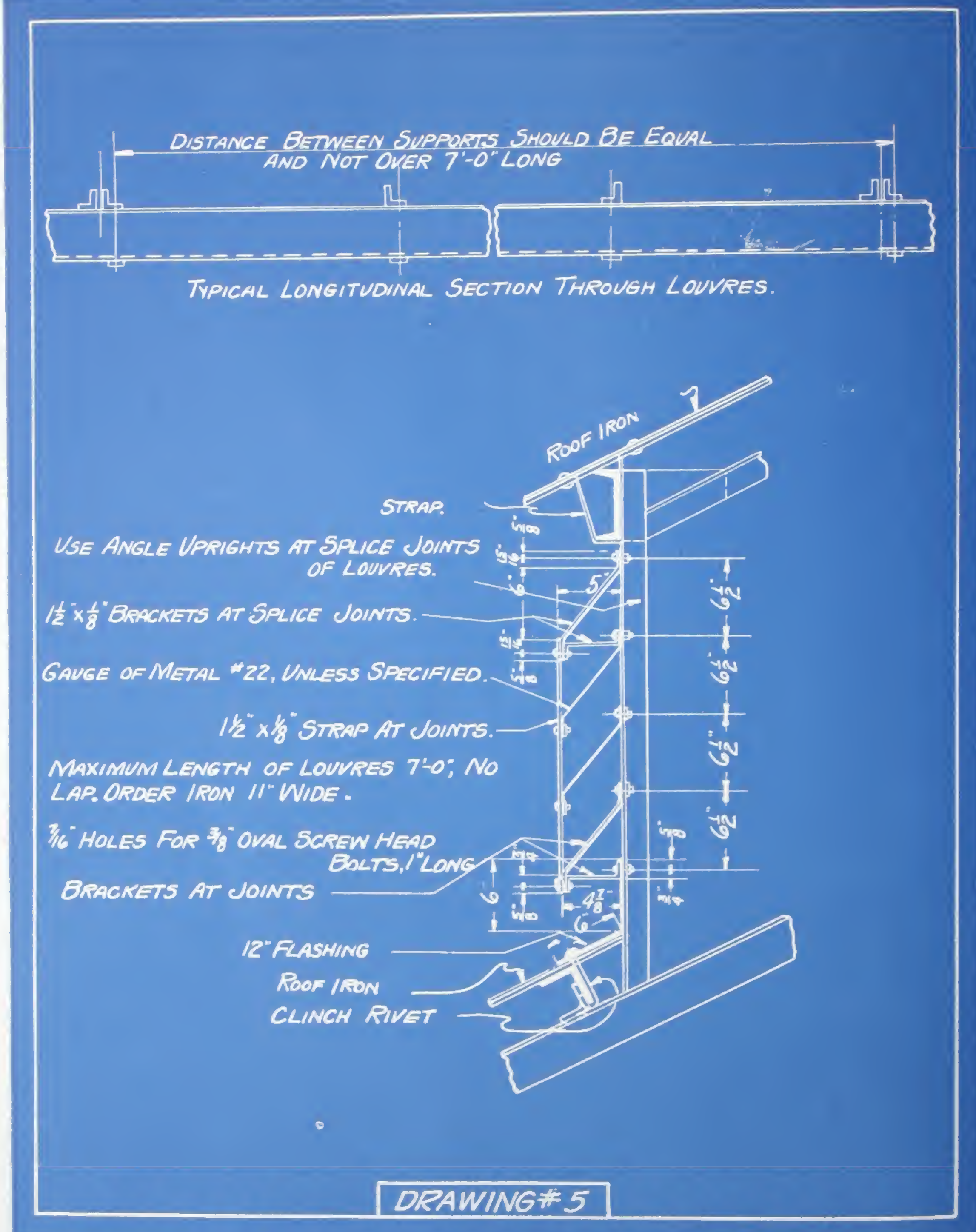


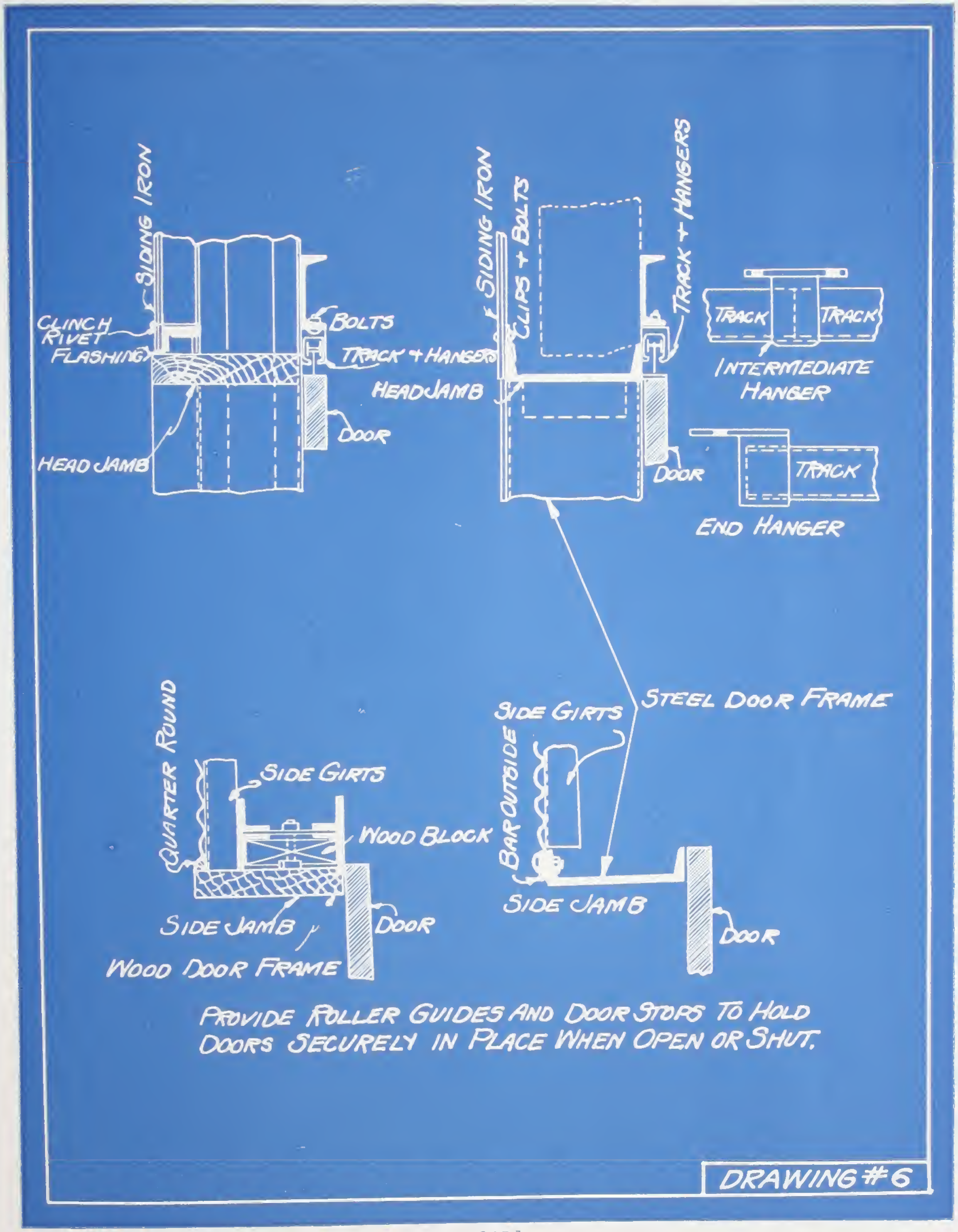
SPANS OF ROOF	GUTTER	CONDUCTOR
UP TO 50	6"	4" EVERY 40'
50 TO 70	7"	5" EVERY 40'
70 TO 100	8"	5" EVERY 40'

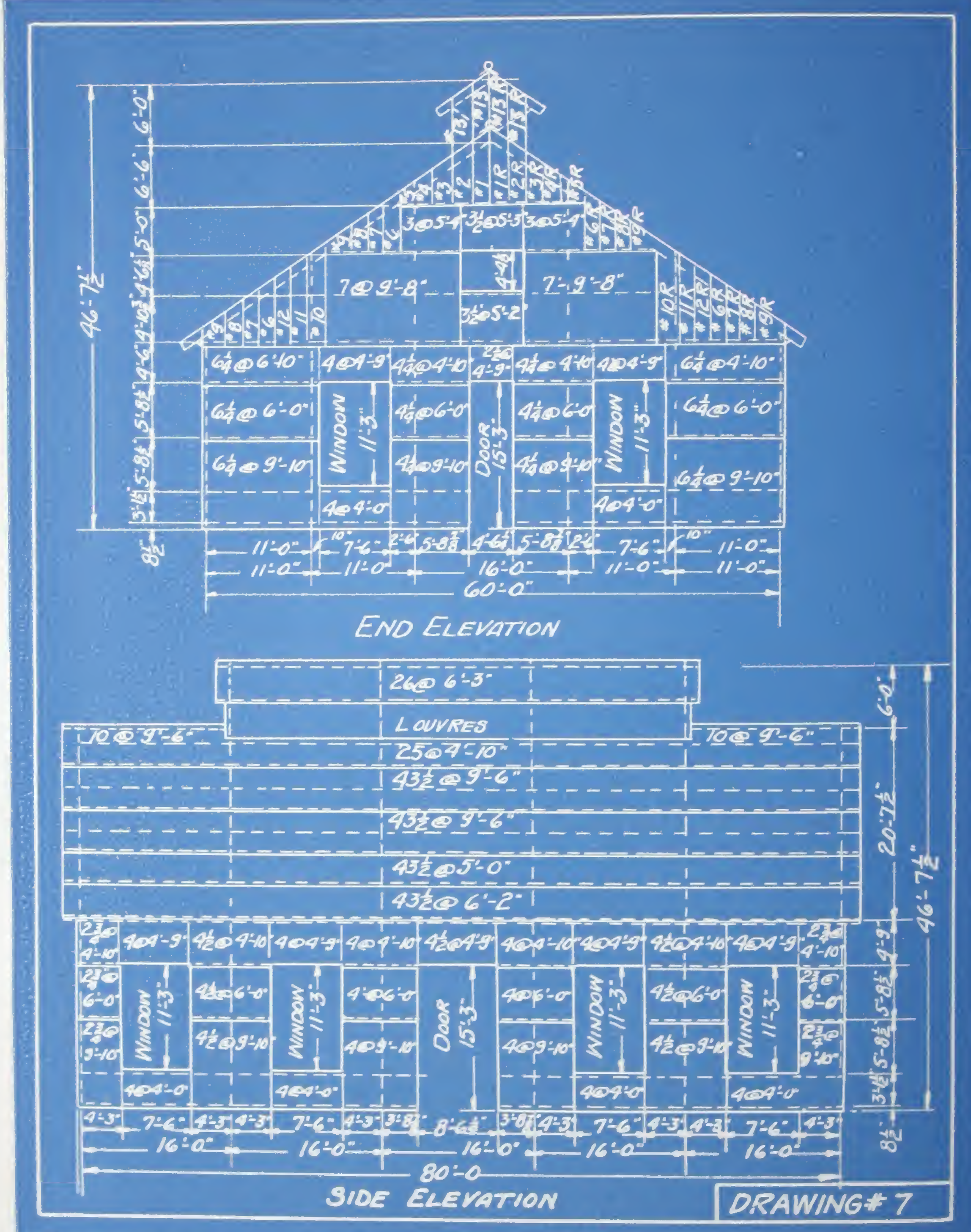
HANGING GUTTERS SHOULD SLOPE AT LEAST 1" IN 15'

MADE OF #24 GALV. IRON UNLESS OTHERWISE SPECIFIED

DRAWING #4

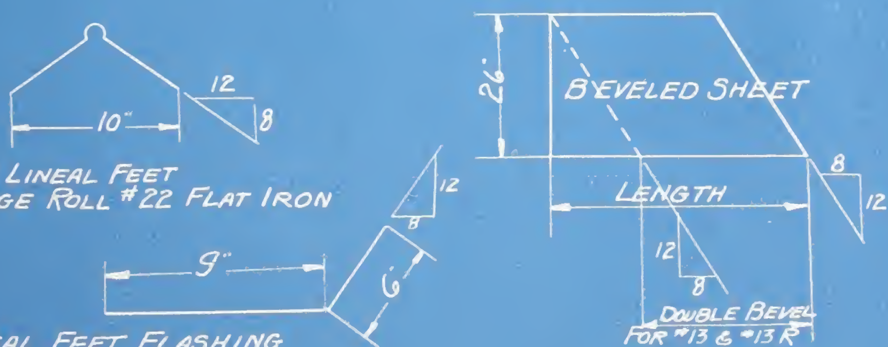

DISTANCE BETWEEN SUPPORTS SHOULD BE EQUAL
AND NOT OVER 7'-0" LONG
TYPICAL LONGITUDINAL SECTION THROUGH LOUVRES.
ROOF IRON
STRAP.
USE ANGLE UPRIGHTS AT SPLICE JOINTS
OF LOUVRES.
1½" x ⅛" BRACKETS AT SPLICE JOINTS.
GAUGE OF METAL #22, UNLESS SPECIFIED.
1½" x ⅛" STRAP AT JOINTS.
MAXIMUM LENGTH OF LOUVRES 7'-0", NO
LAP. ORDER IRON 11" WIDE.
7/16" HOLES FOR 3/8" OVAL SCREW HEAD
BOLTS, 1" LONG
BRACKETS AT JOINTS
12" FLASHING
ROOF IRON
CLINCH RIVET
DRAWING #5


SIDING IRON
CLINCH RIVET
FLASHING
BOLTS
TRACK + HANGERS
HEAD JAMB
DOOR
SIDING IRON
CLIPS + BOLTS
TRACK + HANGERS
HEAD JAMB
DOOR
TRACK
TRACK
INTERMEDIATE HANGER
TRACK
END HANGER
QUARTER ROUND
SIDE GIRTS
WOOD BLOCK
SIDE JAMB
DOOR
WOOD DOOR FRAME
STEEL DOOR FRAME
SIDE GIRTS
BAR OUTSIDE
SIDE JAMB
DOOR
PROVIDE ROLLER GUIDES AND DOOR STOPS TO HOLD DOORS SECURELY IN PLACE WHEN OPEN OR SHUT.
DRAWING #6


END ELEVATION
WINDOW 11'-3"
DOOR 15'-3"
WINDOW 11'-3"
60'-0"
46'-7½"
LOUVRES
26@ 6'-3"
25@4'-10"
43½ @9'-6"
43½ @9'-6"
43½ @5'-0"
43½ @6'-2"
20'-7½"
80'-0
SIDE ELEVATION
DRAWING # 7

CORRUGATED IRON LIST FOR BUILDING

RECTANGULAR SHEETS					BEVELED SHEETS AS PER SKETCH						
NO.	U.S.S.G.	LENGTH	MARKS		NO.	U.S.S.G.	LENGTH	MARKS			
50	#22	4'-10"	ROOFING		4	#24	7'-1½"	2	#1	2	#1R
87	"	5'-0"	ROOFING		4	"	5'-9½"	2	#2	2	#2R
87	"	6'-2"	ROOFING		4	"	4'-5½"	2	#3	2	#3R
52	"	6'-3"	ROOFING		4	"	3'-1½"	2	#4	2	#4R
214	"	9'-6"	ROOFING		4	"	1'-9½"	2	#5	2	#5R
SIDING					8	"	6'-0"	4	#6	4	#6R
48	#24	4'-0"			8	"	4'-8"	4	#7	4	#7R
55	"	4'-9"			8	"	3'-4"	4	#8	4	#8R
87	"	4'-10"			8	"	2'-0"	4	#9	4	#9R
7	"	5'-2"			4	"	10'-0"	2	#10	2	#10R
7	"	5'-3"			4	"	8'-8"	2	#11	2	#11R
12	"	5'-4"			4	"	7'-4"	2	#12	2	#12R
87	"	6'-0"				"					
28	"	9'-8"			8	"	7'-6"	4	#13	4	#13R
87	"	9'-10"				"					



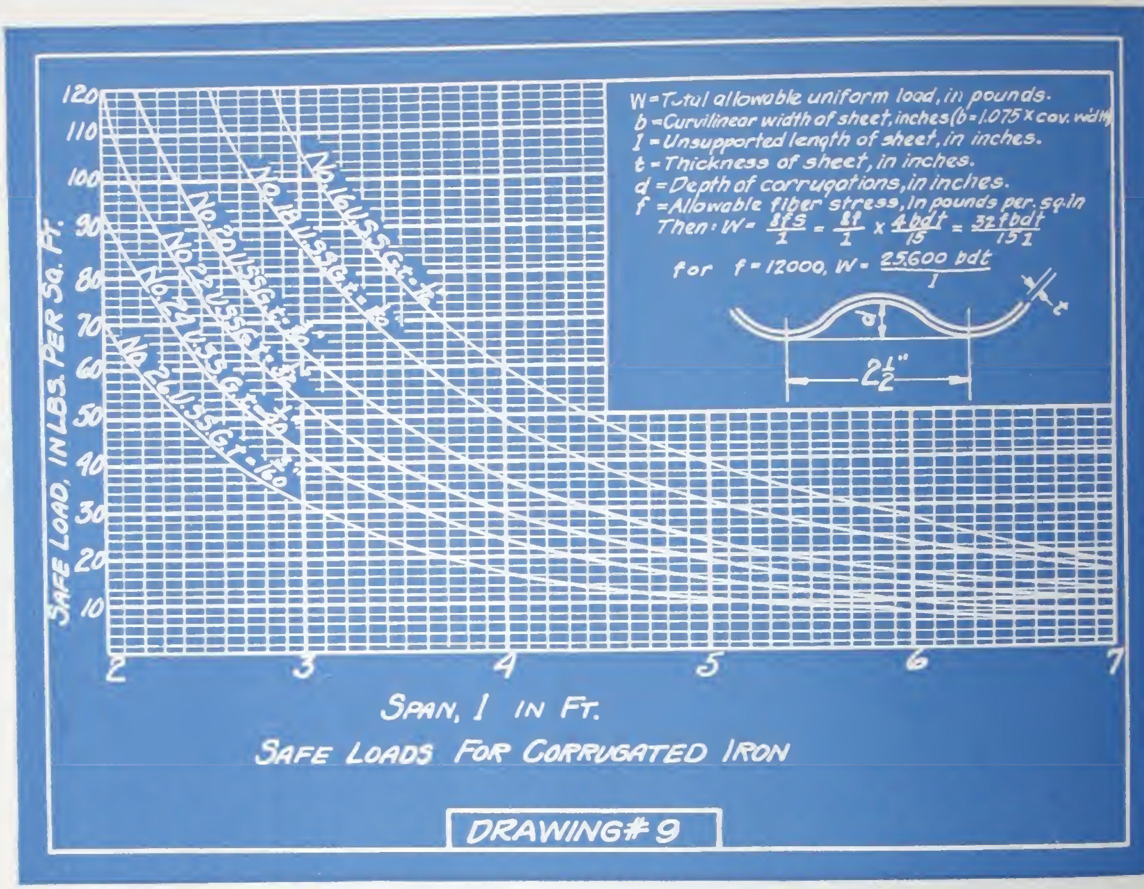
84 LINEAL FEET RIDGE ROLL #22 FLAT IRON

100 LINEAL FEET FLASHING #22 FLAT IRON

ROOFING SHEETS 27½" WIDE CORRUGATIONS 2½"

SIDING SHEETS CORRUGATIONS 2½"

DRAWING # 8



SOME OF THE ADVANTAGES OF CORRUGATED IRON SHEETS

DURABLE: Corrugated iron (pure iron) roofing and siding can be adapted to various kinds of industrial plant buildings, and may be depended upon to give satisfactory service over a longer period of time with less maintenance than other available materials for such use.

STRONG: The corrugations add strength and rigidity to the structure.

WATERTIGHT: By lapping the corrugations of corrugated iron sheets, a watertight joint is assured. If the sheets are put on properly, they will remain in place as long as the building lasts.

EASY TO APPLY: Corrugated iron sheets can be used on wood frame or steel structure. Sheets can be nailed directly to the timbers, or fastened to the purlins, with maximum distance between supports. This work can be done by unskilled labor under the direction of an experienced man.

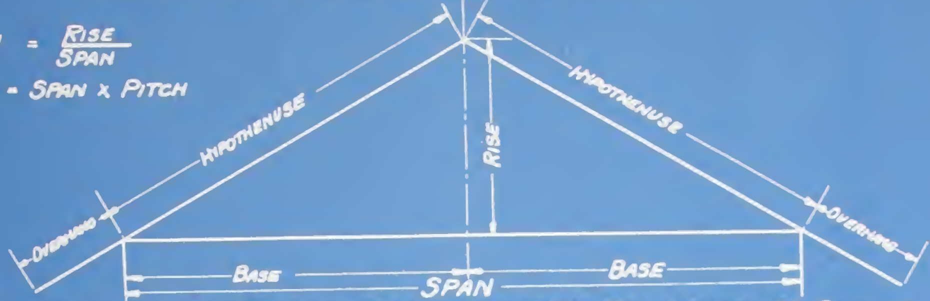
PROTECTS: In addition to protecting from corrosion, metal covered buildings reduce fire and lightning hazards. A metal covered building properly grounded, is immune from damage by lightning. Fire insurance rates on such buildings are considerably lower.

These advantages constitute a saving that is well worth considering, not only for industrial types of buildings, but for other structures where corrugated pure iron sheets are adaptable.

TO FIND LENGTH OF ANGLE OF ROOF WHEN PITCH AND BASE ARE KNOWN.

$$\text{PITCH} = \frac{\text{RISE}}{\text{SPAN}}$$

RISE = SPAN x PITCH



NOTE: OVERHANG MUST BE ADDED TO HYPOTHENUSE FOR FULL LENGTH OF SHEETS

PITCH OF ROOF	RISE PER FOOT	
1/48	½ INCH	BASE x 1.00086 = HYPOTHENUSE
1/24	1 INCH	" x 1.00346 = "
3/48	1½ INCH	" x 1.00777 = "
1/12	2 INCH	" x 1.01379 = "
5/48	2½ INCH	" x 1.02149 = "
1/8	3 INCH	" x 1.03077 = "
7/48	3½ INCH	" x 1.04165 = "
1/6	4 INCH	" x 1.05409 = "
3/16	4½ INCH	" x 1.06800 = "
1/5	4⅘ INCH	" x 1.07703 = "
5/24	5 INCH	" x 1.08333 = "
11/48	5½ INCH	" x 1.10003 = "
1/4	6 INCH	" x 1.11803 = "
13/48	6½ INCH	" x 1.13728 = "
7/24	7 INCH	" x 1.15770 = "
5/16	7½ INCH	" x 1.17758 = "
1/3	8 INCH	" x 1.20185 = "
17/48	8½ INCH	" x 1.22545 = "
3/8	9 INCH	" x 1.25000 = "
19/48	9½ INCH	" x 1.27543 = "
2/5	9⅗ INCH	" x 1.28064 = "
5/12	10 INCH	" x 1.30170 = "
7/16	10½ INCH	" x 1.32876 = "
11/24	11 INCH	" x 1.35656 = "
23/48	11½ INCH	" x 1.38506 = "
1/2	12 INCH	" x 1.41421 = "

PITCH OF ROOF	RISE PER FOOT	
25/48	12½ INCH	BASE x 1.44157 = HYPOTHENUSE
13/24	13 INCH	" x 1.47431 = "
27/48	13½ INCH	" x 1.50518 = "
7/12	14 INCH	" x 1.53659 = "
3/5	14⅖ INCH	" x 1.56205 = "
29/48	14½ INCH	" x 1.56846 = "
5/8	15 INCH	" x 1.60078 = "
31/48	15½ INCH	" x 1.63352 = "
2/3	16 INCH	" x 1.66666 = "
11/16	16½ INCH	" x 1.70018 = "
17/24	17 INCH	" x 1.73405 = "
35/48	17½ INCH	" x 1.76825 = "
3/4	18 INCH	" x 1.80277 = "
37/48	18½ INCH	" x 1.83759 = "
19/24	19 INCH	" x 1.87268 = "
4/5	19⅕ INCH	" x 1.88679 = "
39/48	19½ INCH	" x 1.90804 = "
5/6	20 INCH	" x 1.94365 = "
41/48	20½ INCH	" x 1.97949 = "
7/8	21 INCH	" x 2.01556 = "
43/48	21½ INCH	" x 2.05184 = "
11/12	22 INCH	" x 2.08832 = "
15/16	22½ INCH	" x 2.12500 = "
23/24	23 INCH	" x 2.16185 = "
47/48	23½ INCH	" x 2.19887 = "
1	24 INCH	" x 2.23606 = "

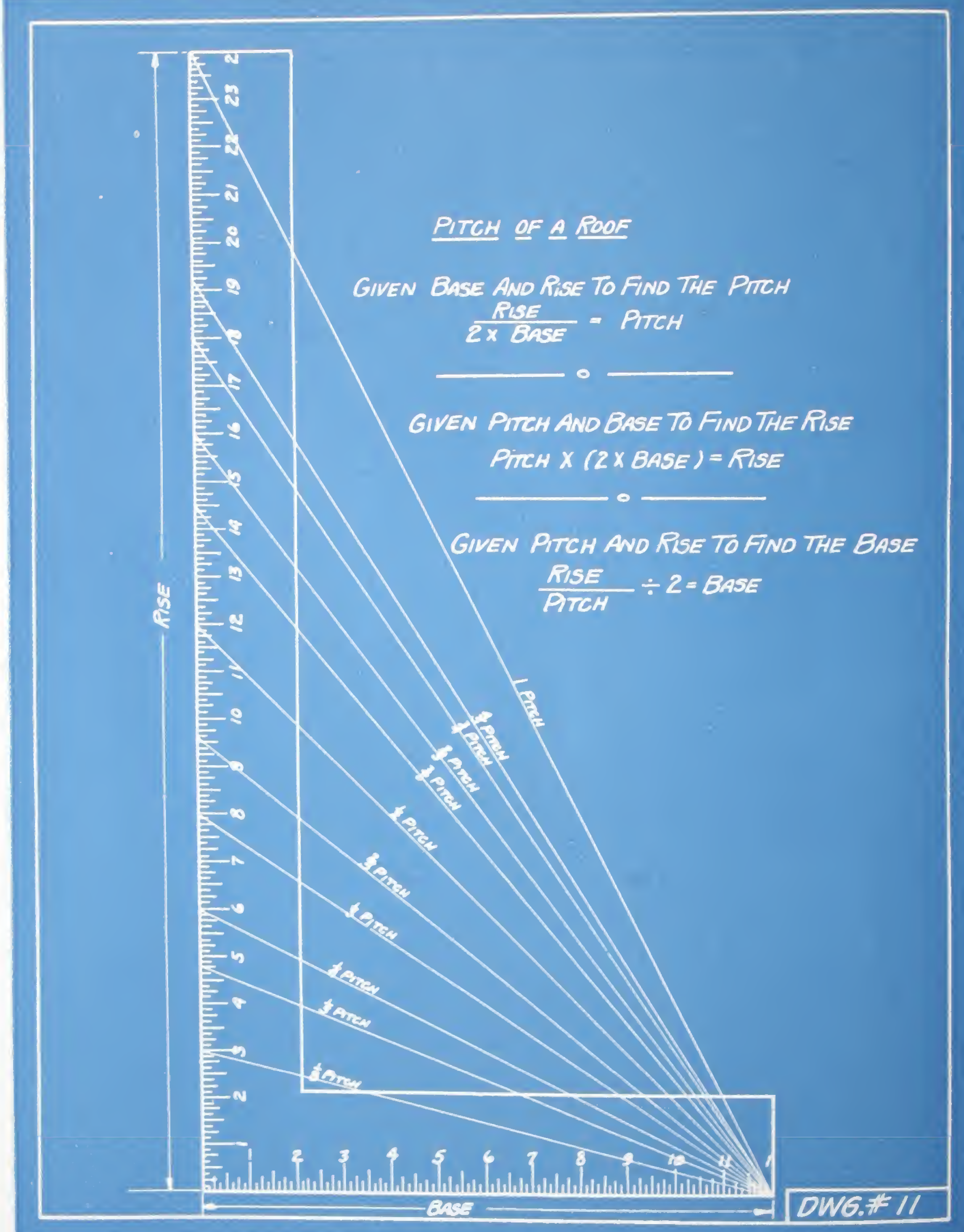
EXAMPLE:

FIND LENGTH OF ANGLE OF ROOF TO BE COVERED - SAME HAVING ⅓ PITCH
36 FT. BASE AND 2 FT. OVERHANG

1.20185 GIVEN IN TABLE FOR ⅓ PITCH
36' BASE
721110
360555
43.26660' HYPOTHENUSE
43.26660' = 43'-3 3/16" APROXIMATELY.

43'-3 3/16" + 2' OVERHANG = 45'-3 3/16"
END LAPS MUST BE ADDED TO THIS LENGTH.

DRAWING # 10


PITCH OF A ROOF
GIVEN BASE AND RISE TO FIND THE PITCH
$\frac{\text{RISE}}{2 \times \text{BASE}} = \text{PITCH}$
GIVEN PITCH AND BASE TO FIND THE RISE
PITCH X (2 X BASE) = RISE
GIVEN PITCH AND RISE TO FIND THE BASE
$\frac{\text{RISE}}{\text{PITCH}} \div 2 = \text{BASE}$
1 PITCH
RISE
BASE
DWG. # 11

Reference Data

The following reference tables contain helpful information in convenient form for the estimator. Drawing No. 10, Page 41, will also prove helpful in figuring the size roofing sheets required.

Standard width of corrugated siding sheets is 26″, and all tables are based on this width except where otherwise noted.

Table 1 Description and area of sheets

Table II Weight per one hundred square feet, galvanized corrugated sheets

Table III Square feet of lapped sheets to cover one hundred square feet exposed surface

TABLE I

Description and Areas of Corrugated Sheets

Description of Sheets							Area of Sheets					
Corrugations				Width in Inches		Length of Sheet Inches	Square Ft. in 1 Sheet			Sheets in 100 Sq. Ft.		
Width Inches		Depth Inches	No. Per Sheet	Full Sheet	Covers		Corrugations			Corrugations		
Nominal	Actual						5″	3″ 2½″	1¼″	5″	3″ 2½″	1¼″
5	5	⅞	6	28	25	60	11.67	10.83	10.42	8.57	9.23	9.60
3	3	9/16	9	26	24	72	14.00	13.00	12.50	7.14	7.69	8.00
*2½	2-2/3	½	10½	27½	24	84	16.33	15.17	14.58	6.12	6.59	6.86
2½	2-2/3	½	10	26	24	96	18.67	17.33	16.67	5.36	5.77	6.00
1¼	1¼	⅜	20	25	23¾	120	23.33	21.67	20.83	4.29	4.62	4.80

*2½″ for 27½″ width.

Standard lengths are 5, 6, 7, 8, 9, and 10 feet.

TABLE II

Weight Per 100 Sq. Ft.—Galv. Corr. Sheets

Galvanized Sheets—Weight Per 100 Square Feet														
Corrugation Inches	U. S. Standard Gauge													
	10	12	14	16	18	20	21	22	23	24	25	26	27	28
5		486	352	285	231	178	164	151	137	124	111	97	90	84
3		488	353	286	232	178	165	151	138	125	111	98	91	84
*2½	631	494	358	290	235	181	167	153	140	126	113	99	92	85
2½	623	488	353	286	232	178	165	151	138	125	111	98	91	84
1¼						186	172	158	144	130	116	102	95	88

*2½" for 27½" width

TABLE III

Square Feet of Lapped Sheets to Cover 100 Sq. Ft. Exposed Surface

Actual Square Ft. of 2½" Standard Corrugated Sheets to Cover 100 Square Ft. of Roof 96" Long Sheets						
Side Lap	End Lap Inches					
	1	2	3	4	5	6
1 Corrugation	110	111	112	113	114	115
1½ Corrugations	115	116	117	118	119	120
2 Corrugations	119	120	121	122	123	124

Anti-Condensation Lining

Corrugated iron roofs on buildings housing machinery or products affected by moisture, should be insulated to prevent condensation of vapor on the inside of the metal roof. The corrugated iron roofing sheets should be laid on tight tongue and groove wood sheathing or else an anti-condensation lining should be provided on the underside.

Figures 1 and 2 illustrate condensation linings which are economical and will offer good pro-

tection. The anti-condensaton lining is built up by covering a stretched wire netting with asbestos felt and paper. The wire netting is stretched tight and supported by the purlins.

The fundamental requirement is a good insulation between the chilled roofing material and

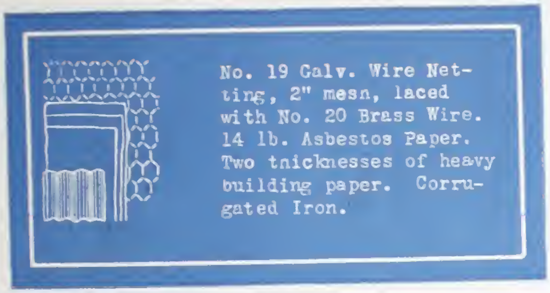


Figure One

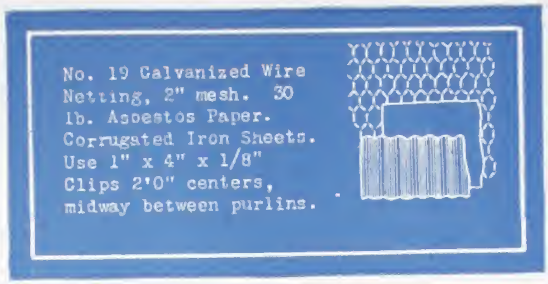


Figure Two

the inside moisture laden air. Any cellular material will meet this requirement. Coatings of paint, asphaltum, or similar materials applied on the sheets will not prevent condensation as they do not give the kind of insulation that is necessary.

THIS TRADE MARK IN BLUE
IS PLAINLY STAMPED
ON EVERY GALVANIZED
ARMCO Ingot Iron SHEET
TRADE MARK
ARMCO
REG. U.S. PAT. OFF.
M-26
8-4
26
GAUGE
INGOT IRON
6-8-4-8846
This Blue Triangle appearing on the sheet metal built into your structures will assure a high quality pure iron
Properly Protected

The Development, Uses, and Service Life of Pure Iron

DEVELOPMENT: Iron was in general use by the trades three score years ago. However, its corrosion-resisting characteristics was not recognized at that time. This was due to lack of comparison—there being no other metal that took its place in the construction field.

The development of steel in large quantity production drew the attention of metal workers and designers away from the pure irons which had to be made by slow, expensive processes that allowed only small quantity production. It was not many years before the futility of using ordinary steel for all applications was recognized. Iron was needed to resist corrosive conditions, and it had to compete with steel in price. The result was—a new method of producing pure iron in commercial quantities.

The American Rolling Mill Company responded to the call for a rust-resisting pure iron and after much research and expense produced ARMCO Ingot Iron. Demand for this long-lasting iron has grown until the ARMCO organization is the world's largest producer of special analysis iron and steel sheets for exacting uses.

USES OF PURE IRON: Pure Iron is manufactured by this company in galvanized sheet form for roofing and roof drainage parts, cornices, marquees, heating and ventilating ducts, etc., and in galvanized corrugated form for roofing and siding on industrial types of buildings.

ARMCO Ingot Iron is widely used by fabricators of building products. Following are some of these products:

Metal Lath (Painted and Galvanized)
Tanks
Doors and Partitions
Window Frames
Porcelain Enameled Shingles
Heating and Ventilating Systems
Refrigerators
Water Softeners
Clothes Dryers
Air Washers
Furnaces
Ventilators
Signs

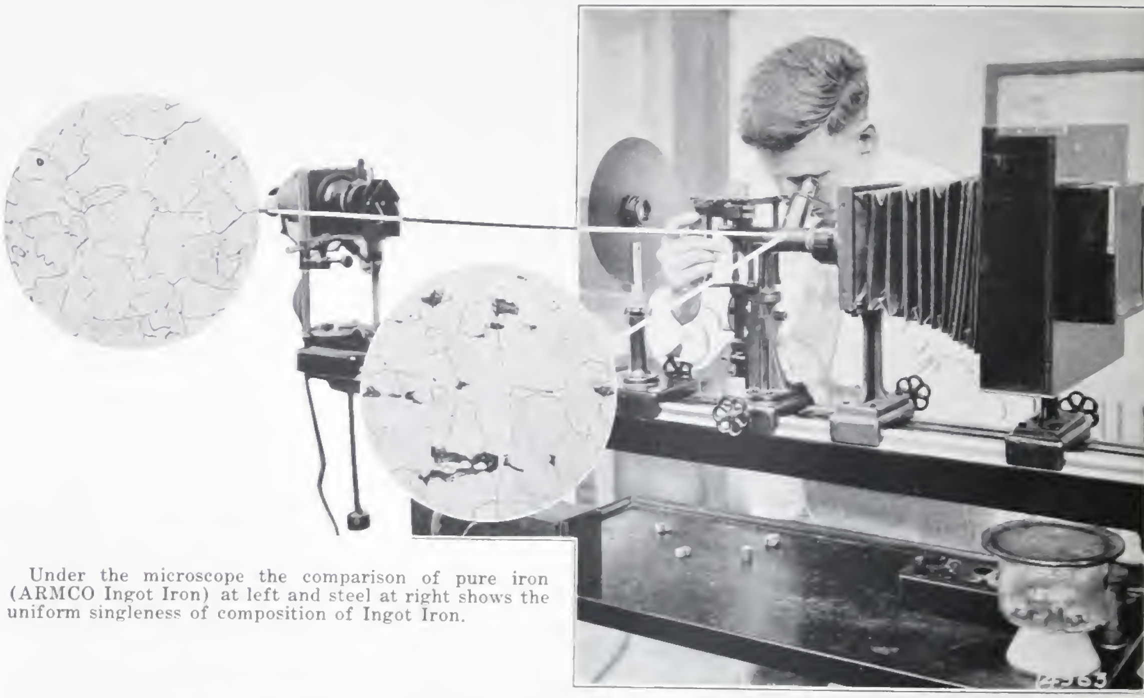
SERVICE LIFE: Because the rust-promoting impurities have been practically eliminated (the sum total of carbon, manganese, phosphorus, sulfur, and silicon is always less than 16/100 of 1%), the electro-chemical action that causes corrosion is reduced to a minimum, which results in long service life.

The uniformity of Ingot Iron, which is the result of exacting refining and annealing practice, is another important factor in its longevity.

Also, with the purest possible commercial iron base, and the finest grade of tightly adherent zinc coating, ARMCO Ingot Iron is especially adaptable to even the most severe sheet metal service requirements.

Twenty years of general satisfactory service under varying conditions has given ARMCO Ingot Iron a reputation for durability which is well known among the building professions and trades.

Why Pure Iron Resists Corrosion



Under the microscope the comparison of pure iron (ARMCO Ingot Iron) at left and steel at right shows the uniform singleness of composition of Ingot Iron.

What Is Corrosion?

Corrosion is the destruction of metal by electro-chemical action. This action is commonly spoken of, in the case of iron and steel, as rusting. The attacking force may be the atmosphere (if damp), fluids, acids, rainfall, or briefly, any medium which is capable of conducting an electric current. How this electric current is generated is simply explained by describing an ordinary battery, since the action of a battery is but a practical application of the same chemical process that takes place when metal rusts.

The Chemical Action of a Battery

Over a hundred years ago it was discovered that an electric current was generated by any two different metals that were placed in a liquid capable of conducting electricity, whenever a connecting circuit was placed between the metals.

This action can be shown by setting up a small battery, using ordinary tap water, a strip of iron and one of copper, and connecting them with a wire circuit in which a small current indicator is placed to show the flow of electricity.

Any two different metals placed in any liquid capable of carrying current will make such a battery, though some metals make stronger batteries than others.

The generation of an electric current requires that something be used up. It has been found that one of the two metals in a battery is destroyed or "burned up" chemically.

As long as this one metal continues to be destroyed by dissolving into the liquid, the current will flow. In the case of a battery, this action (which is appropriately called an ELECTRO-CHEMICAL action) is useful, since the current produced can be made to ring doorbells, run clocks, operate ignition coils, and do similar work requiring small current.

On the other hand, however, scientific research has established the fact that corrosion is caused by this very same "electro-chemical" action and the result is the destruction of our iron and steel.

Corrosion or Battery Action in Iron and Steel

How corrosion of iron and steel is caused by the destructive action of innumerable tiny batteries can best be understood by first considering the composition of iron and steel. Ordinary commercial iron is a mixture of the element iron itself and small amounts of such foreign impurities as carbon, manganese, phosphorus, copper, sulfur, and silicon. Steel is composed of the element iron together with greater amounts of carbon and manganese, along with the other impurities.

In the manufacture of iron and steel, these impurities are probably uniformly distributed throughout the mass of metal as long as the metal is in a white hot liquid condition in the refining furnace. But when the liquid metal is poured into moulds and allowed to solidify, these impurities tend to segregate, or separate into unevenly distributed portions throughout the solid metal.

When the solid iron or steel with its unevenly distributed impurities is rolled out into plate and sheets, the relative location of the impurities is of course unaltered.

Remembering that the only necessities for the creation of a battery are two different metals, a current-conducting liquid, and a connection between the two metals, we find these requirements duplicated when a sheet of steel or impure iron is exposed to the atmosphere.

The segregated impurities are in metallic connection with the iron itself. The iron of the sheet furnishes one element of the battery, the impurities the other. All that is now needed to start electro-chemical action is the current-conducting liquid. Ordinary rainwater, condensed moisture, moist air containing weak acid fumes from industrial plants, salt air, and even moist gases, will conduct current.

Therefore, when any of these atmospheric mediums come in contact with the metal sheet, a great many tiny batteries over the entire metal surface are at once started into action and destruction, or corrosion, proceeds. Whether the iron itself is "burned up" chemically or the impurity destroyed, makes no difference, since in either case it is the sheet that suffers.

In some cases, electro-chemical action may be set up and corrosion produced by conditions external to the metal. It has been found that lack of uniformity in the distribution of dissolved salts, acids, or gases in solutions in contact with metal may, under certain conditions, furnish the necessary essentials for a battery.

Why Pure Iron Resists Corrosion

Since it is manifestly impossible to prevent the action of the natural law which causes segregation (uneven distribution) of impurities during solidification of molten steel, it is logical to assume that the best way to prevent this segregation is to remove, during the refining process, the impurities which segregate.

This is exactly what is done in the making of ARMCO Ingot Iron. The impurities are eliminated to the lowest possible amount. The total of the carbon, manganese, phosphorus, sulfur, and silicon in the metal does not exceed sixteen hundredths (.16) of one per cent—the purest iron made.

When a sheet of this pure iron is exposed to the atmospheric conditions that start corrosion, the amount of battery action is held to the lowest possible point because of the minimum of impurities present.

That this retardation of corrosion by the use of pure iron has confirmed the universally accepted scientific explanation of corrosion as an electro-chemical action, is proved by twenty years superior service of ARMCO Ingot Iron.

Identifying Characteristics of Pure Iron

ARMCO Ingot Iron possesses definite chemical and physical characteristics which set it apart as different and distinctive from all other ferrous metals. Because of its method of manufacture and state of refinement, it is:

1. CHEMICALLY DIFFERENT: The purest iron made—no other sheet meets Ingot Iron's purity standard.

2. METALLURGICALLY DIFFERENT: Degasified, uniform, slagless. A microscopical examination reveals the characteristic ferrite (pure iron), well annealed grain structure.

3. PHYSICALLY DIFFERENT: Soft, ductile, workable. Tensile strength of dead soft annealed material 38,000 pounds per square inch, elongation not less than 22% in 8 inches, yield-point not less than 50% of tensile strength.

4. WORKING TEMPERATURE DIFFERENT: Possesses the critical temperature range characteristic of pure iron. Rollers and forgers can classify ARMCO Ingot Iron by its behavior when worked within its critical temperature range— 1562° F (850° C) to 1922° F (1050° C).

5. GREATER RESISTANCE TO SOLUBILITY IN MOLTEN ZINC: Research investigators can classify ARMCO Ingot Iron by its resistance to solubility in molten zinc.

Further substantiating this fifth point, attention is directed to the following remarks quoted from "Galvanizing and Tinning," by W. T. Flanders, pages 18 to 20 inclusive:

> "The laws of physics teach us that an impure substance will go into solution more rapidly than a pure one, and we do not find exceptions when dissolving iron in zinc. The purer the iron the more slowly it goes into solution. This is the reason that the old-fashioned puddled iron lasted so much longer than the modern steel. Now that ingot iron is being commercially produced, it has been very easy to demonstrate this fact in a scientific manner.
>
> "These statements are borne out and given additional weight by a comparison of galvanized ARMCO Iron sheets with galvanized mild open hearth steel sheets."

Because of these identifying characteristics ARMCO Ingot Iron is universally chosen as the standard of pure iron not only for industry, but by scientists for experimental purposes and intricate investigations.

NOTE: The question is often asked, "What is the difference between iron and steel?"

Dr. Albert Sauveur, Professor of Metallurgy, Harvard University, has clarified this question with the following classification and definitions of ferrous metals:

"Commercial Iron—The element iron as pure as it can be commercially produced.

"Ingot Iron—Commercial Iron which has been produced in fluid condition and cast.

"Wrought Iron—A ferrous metal which is malleable and which has been produced from a pasty condition.

"Steel—A malleable alloy of iron and carbon usually containing substantial quantities of manganese.

"Following this classification, such a material as ARMCO Ingot Iron may be further defined as 'ingot iron' produced in an open-hearth furnace and containing not more than 0.02 per cent carbon and not more than 0.035 per cent manganese."

Economy of Using Pure Iron

ARMCO Ingot Iron costs roughly one cent a pound more than steel. This 20% to 25% differential in material cost is reduced to from 5% to 10% increased cost when the completed job is considered.

Comparing the cost with comparable gauges in copper and zinc (say, 24 gauge galvanized iron, 16 ounce copper, and 9 or 10 gauge zinc) ARMCO Ingot Iron costs are about one-fourth that of copper and one-half that of zinc. These figures are based not upon an equal weight of each material, but upon the covering area using the gauges most commonly recommended for that same class of work.

As the architect and engineer well know from experience, the labor cost is the major item in building construction, and it is real economy to protect this large investment in labor costs by employing durable materials which will postpone costly replacements.

Our experiences in investigating costs on various types of sheet metal jobs have shown us that it costs about 5% more to use ARMCO Ingot Iron for flashings, gutters, downspouts (that is, the residential type of roofing job), than if steel were used. Where a sheet metal roof, as well as these roof drainage parts, is considered, the cost of using ARMCO Ingot Iron runs about 11% more than for a steel job. The basis of figuring this increased cost is illustrated in the following figures which are actual costs on a specific roof job.

The engineer specified 22 gauge ARMCO Ingot Iron. The comparative cost of using ARMCO Ingot Iron and steel were:

Cost of material Galvanized ARMCO Ingot Iron:
350 sq. 22 ga. at $7.17 per square------$2509.50

Labor, overhead, and profit:
350 sq. at $9.87 per square------------$3454.50

Cost of ARMCO Ingot Iron job----------$5964.00

Cost of material in Galvanized Steel:
350 sq. of 22 ga. at $5.50 per square----$1928.50

Labor, overhead and profit:
350 sq. at $9.87 per square------------$3454.50

Cost of Galvanized Steel job------------$5383.00

Increased cost of job using ARMCO----$ 581.00

Percentage increased cost using ARMCO 10.8%

But this is only the first cost; the cost per service year when Ingot Iron is used, has been found to be far less. True cost consists of the sum of original cost and maintenance, divided by the number of years of service.

Thus, on the particular contract figured above, if steel lasted ten years, ARMCO Ingot Iron would only have to last eleven years and ten months to have an equally low cost per service year. Or, if steel should last twenty years, where ARMCO Ingot Iron had given twenty-three years and eight months service, it would begin paying handsome dividends.

And the record of 20 years of service in widely varying fields of service, shows that Ingot Iron gives much more than this 10% to 11% longer service.

It is no paradox to say, "Pay a Little More That the Cost May Be Less," for it is cost per year of service life that counts.

NOTE: On any job, the workability of the material is always an important consideration. This quality is especially essential to best results in forming sheet metal to intricate designs, such as for cornices, marquees, and the like.

Workability affects cost.

On large jobs involving considerable sheet metal forming work, contractors have learned that pure iron sheets, because of the uniformity and greater ductility of iron, have saved a good part of the difference in price over ordinary galvanized sheet metal. And workmen like to use it.

So, pure iron saves in other ways besides its low cost per service year.

Safe Loads for Rectangular Wood Beams

Safe Loads in Pounds Uniformly Distributed For Rectangular Wood Beams One Inch Wide
For an Allowable Fiber Stress of 1000 pounds per square inch

Depth of Beam In Inches

Span In Feet	4	6	8	10	12	14	16	18	20	22	24
4	440	1000	1780	2780	4000	5440	----	----	----	----	----
5	360	800	1420	2220	3200	4360	----	----	----	----	----
6	300	670	1190	1850	2670	3630	----	----	----	----	----
7	250	570	1020	1590	2290	3110	----	----	----	----	----
8	220	500	890	1390	2000	2720	----	----	----	----	----
9	200	440	790	1240	1780	2420	3160	4000	4940	5980	7110
10	180	400	710	1110	1600	2180	2840	3600	4440	5380	6400
11	160	360	650	1010	1460	1980	2590	3270	4040	4890	5820
12	150	330	590	930	1330	1820	2370	3000	3700	4480	5330
13	140	310	550	860	1230	1680	2190	2770	3420	4140	4920
14	130	290	510	790	1140	1560	2030	2570	3180	3840	4570
15	120	270	470	740	1070	1450	1896	2400	2960	3590	4270
16	110	250	440	690	1000	1360	1780	2250	2780	3360	4000
17	110	240	420	650	940	1290	1670	2120	2610	3160	3770
18	100	220	400	620	890	1210	1580	2000	2470	2990	3560
19	90	210	370	590	840	1150	1500	1900	2340	2830	3370
20	90	200	360	560	800	1090	1420	1800	2220	2690	3200
21	85	190	340	530	760	1040	1350	1710	2120	2560	3050
22	80	180	320	510	730	990	1290	1640	2020	2440	2910
23	80	170	310	480	700	950	1240	1570	1930	2340	2780
24	--	160	300	460	670	910	1190	1500	1850	2240	2670
25	--	160	280	440	640	870	1140	1440	1780	2130	2560
26	--	150	270	430	610	840	1090	1380	1710	2070	2460
27	--	150	260	410	590	810	1050	1330	1650	1990	2370
28	--	140	250	400	570	780	1020	1290	1590	1920	2290
29	--	140	240	340	550	750	980	1240	1530	1850	2210
30	--	130	240	370	530	730	950	1200	1480	1790	2130
31	--	130	230	360	520	700	920	1160	1430	1730	2060
32	--	125	220	350	500	680	890	1130	1390	1680	2000
33	--	120	210	340	480	660	860	1090	1350	1630	1940
34	--	120	210	330	470	470	640	1060	1310	1580	1880
35	--	110	200	320	460	600	810	1030	1270	1540	1830

The weight of the beam need be considered only when the ratio of span to depth of beam is large. For concentrated loads at the middle of a beam, divide table safe loads by 2. For fiber stresses other than 1000 lbs., correct safe loads of table. (From The American Civil Engineer's Handbook.)

Combined Dead and Live Loads for Various Types of Roofs

In north temperate climates where roof loads are not fixed by building laws, ordinary roofs up to 80 feet span should be designed to carry as a minimum the following loads per sq. ft. of exposed surface (loads applied vertically) which provides for total dead, and live load combined.

Types of Roof Covering	Combined dead and live load per square foot pounds
Corrugated iron roofing on sheathing or purlins	40
Gravel or Composition Roofing:	
On sheathing, slope less than 2 inches per foot	50
On sheathing, slope greater than 2 inches per foot	45
On 3 inch flat tile or cinder concrete	60
Slate:	
On sheathing or purlins	50
On 3 inch flat tile or cinder concrete	65
Tile on iron purlins	55
Glass	45

In climates where snow is not likely to occur, the above minimum loads may be reduced by 10 pounds. In no case, however, should the roof members be designed to carry a total dead and live load of less than 40 pounds.

Recommended Specifications for Flat and Corrugated Galvanized Iron Sheets

Scope

1. The following specifications cover flat and corrugated iron and steel sheets.

Physical Properties and Tests

2. (a) The weight of the zinc coating shall conform to the requirements specified in Table I (or in note below it). The weight of coating is the total coating, expressed in ounces, on both sides of a sheet 1 foot square.

TABLE I

Recommended Standard Weight Coating Specifications For All Galvanized Sheets

Galvanized Sheets Gauge No.	Weight of Galv. Sheets Oz. per Sq. Ft. Min.	Nom.	Max.	Average Weight of Coating, Oz. per Sq. Ft.
10	87.9	92.5	97.1	1.75
12	68.9	72.5	76.1	1.75
14	49.9	52.5	55.1	1.75
16	40.4	42.5	44.6	1.50
18	33.6	34.5	35.4	1.50
20	25.8	26.5	27.2	1.50
22	21.9	22.5	23.1	1.50
24	18.0	18.5	19.0	1.50
26	14.1	14.5	14.9	1.40
28	12.2	12.5	12.8	1.40

NOTE: A 2½ oz. coating will be supplied at a nominal extra cost, consistent with the additional cost of the added zinc.

(b) The sheets shall be coated with a grade of zinc equal to or better than Prime Western.

(c) The figure for weight of coating shall be the average of the analytical determinations from three test specimens 2¼ inches square, cut from the middle and ends of the test specimen taken as in Section 4; provided, however, that the coating on any one of the three specimens tested must show at least 75% of the average weight of coating specified as shown in Table I (or in note below it).

(d) The weight of zinc coating shall be determined by hydrochloric acid — antimony chloride method recommended by the United States Bureau of Standards and described in their Circular No. 80. The weight of coating, in ounces per square foot, is numerically equal to that determined in grams from a sample 2¼ inches square.

3. Base Metal Tests: Any part of the test specimen specified in Section 4 shall stand being bent cold through 180° flat on itself without fracture of the base metal. The bend may be made in any direction.

4. Test Specimens: A rectangular test specimen shall be cut transversely across the middle of the sheet, the ends terminating within 1 inch of the sides of the sheet. The samples for coating test shall be cut from the ends and middle of this strip.

5. Number of Tests: (a) One determination of each of the tests specified shall be made from one sheet in each lot of 1000 sheets or fraction thereof, of each gauge and specified coating on each order.

(b) If any test specimen fails to meet the requirements of the specification, a retest will be allowed from two other sheets in the same lot, both of which shall meet the requirements.

Permissible Variations

6. The sheets shall conform to the dimensions specified with the following permissible variations:

(a) The width shall be not less than that specified, but may be 1/4 inch over for sheets 48 inches or less in width, and 3/8 inch over for sheets over 48 inches in width.

(b) The length shall be not less than that specified, but for sheets 96 inches or less in length it may be 3/4 inches greater. For each 24 inches or fraction thereof above 96 inches, the permissible variation may be increased 1/4 inch over 3/4 inches.

(c) When sheets are required accurate to size, they shall be ordered "re-squared." Re-squared sheets shall be not less than the ordered width and length and shall be in excess by not more than 1/16 inch unless wider than 48 inches or longer than 120 inches, in either of which cases the excess tolerance shall be 1/8 inch. Should the sheets be resquared before galvanizing, double the foregoing tolerances are permissible.

Finish

7. The finished sheets shall be of first-class commercial quality, free from injurious defects, such as blisters, flux, and uncoated spots.

Index

Note: "Industrial Buildings" pertains to those buildings roofed or roofed and sided with corrugated iron. In all cases where a particular type of building is not mentioned, or when the subject does not give the clue, the reference pertains to other types of buldings than the industrial type as defined here.

Suggestions Invited

We shall appreciate any suggestions you may have that will help make this handbook more helpful to architects, engineers, and others interested in galvanized iron for roofs and roof drainage parts.

Please address communications to the Architects' Sheet Metal Service Bureau, ARMCO, Middletown, Ohio.